NHS England Carbon Emissions Carbon Footprinting Report

September 2008 (Updated August 2009)

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Updates to report (August 2009)

The following updates have been made to the report, based on feedback received on the original September 2009 report, in order to provide greater clarity, provide further explanation to certain sections and to correct minor errors:

- pp.13-14: The SPA and MRIO analyses completed for the medical equipment and pharmaceutical sectors are explained in more detail
- pp.32-51: Appendix B – sections headings numbered correctly
- pp. 48-51: Tables 2 and 3 added to provide greater clarity of SPA analysis results, and layer 2 of Figures 13 and 14 explained in more detail.
- pp. 64-69: (Appendix B1.1): Table data updated to give intermediate expenditure and associated carbon intensities and carbon emissions for each of the 178 SIC sectors.
- p.70: (Appendix B1.2): assumptions for patient and visitor travel clarified
- p.73 (Appendix B1.3): the Defra emissions sources for this study and the emissions modelling to 2020 are contrasted.
- p.75: (Appendix B2.1): Scope 1 and 3 data values corrected, and now match Figure 7 (p.16).
- pp. 82-85: (Appendix B3): column added in table to include NACE industry numbers 1-178.

Executive Summary

Background

The NHS has produced an NHS England Carbon Reduction Strategy for consultation as part of a broader sustainable development agenda.[1]
To support and inform this process, the Sustainable Development Commission (SDC) has completed a carbon footprinting study covering all NHS England activities.
The carbon footprinting report summarises NHS England carbon dioxide (CO_2) emissions for the years 1992-2004 in three primary sectors - travel, building energy use and procurement - and their associated sub-sectors.

Aims

The study and report aim to help prioritise key action areas in the NHS England Carbon Reduction Strategy, and to provide an evidence base for future NHS England carbon management.

Key findings

The key findings and conclusions of the study are:

1. NHS England's carbon footprint for 2004 was estimated to be **18.61 $MtCO_2$**, which represents 25% of England's public sector emissions.

2. We can quantify potential CO_2 reduction targets for NHS England in line with those currently laid out by Government. Starting from 1992 baseline emissions of 16.47$MtCO_2$ (compared to national emissions targets baseline year of 1990), NHS England would have to limit its emissions as follows:

    - 26-32% reduction by 2020: NHS England emissions limit = 11.20-12.20 $MtCO_2$
    - 60% reduction by 2050: NHS England emissions limit = 6.58 $MtCO_2$

3. **The carbon footprint increased by 12% from 1992-2004.** Within this overall period, carbon emissions fell by 5% from 1992-1998, but then rose by 18% from 1998-2004. The key reason was that expenditure in this period outpaced any improvements in energy efficiency, carbon intensity or improved sustainable practices. This resulted in a 3% per year rise in emissions in the latter period.

4. Procurement forms 60% of the emissions for which NHS England is responsible; within the procurement sector pharmaceuticals are the largest sub-sector, making up 22% of total emissions. This is equivalent to either travel or building energy use emissions.

5. Further analysis was carried out into the origins of carbon emissions from the pharmaceuticals industry. This identified that 80% of emissions are directly from the pharmaceutical industry and are mainly due to the energy used in manufacturing plants. It follows that the priority for these industries would be to reduce emissions from energy use in their own manufacturing processes, rather than 'external' areas such as transportation or suppliers.

6. There are significant differences in the carbon intensities (tCO_2/£) of both pharmaceutical and medical equipment items according to world region of production. The data suggests that whilst purchase of goods from non-OECD countries can be beneficial in economic terms, they may be less attractive on a carbon basis.

7. In the travel sector, the majority (60%) of emissions are those from patients/visitors, with NHS travel (e.g. commuting, business and Patient Travel Services travel) accounting for the remaining 40% of travel emissions.

8. Electricity makes up 55% of overall emissions in the building energy sector, with on-site emissions from heating/hot water consumption forming the other 45%. Gas use is estimated to cause 90% of heating/hot water sub-sector emissions.

[1] *Saving Carbon, Improving Health* A draft carbon reduction strategy for the NHS in England. NHS England (2008) www.sdu.nhs.uk

Recommendations

We have identified a number of recommendations to NHS England to take action on carbon emissions:

1. NHS England should base its carbon reduction strategy on this carbon footprinting report, and work to develop an ambitious programme of action to cut emissions.

2. NHS England should set a challenging 2020 emissions target in its carbon reduction strategy, and outline policy interventions which will have a real impact on emissions.

3. Within procurement, there should be a focus on the sub-sectors with the largest carbon impacts. Examples of areas of study for the NHS could include:

    - Pharmaceuticals: Examine usage/wastage of pharmaceuticals; work with key manufacturers on lowering emissions; study the carbon intensities ($kgCO_2/£$) by world region for generic and R&D based medicines; investigate alternative models of care which may be less drug intensive.

    - Medical equipment: Investigate the breakdown of consumption by category – for example assessing the carbon impacts of use of single use items and their alternatives

4. Future input data to the carbon modelling work should be strengthened by:

    - Making mandatory the requirement for building energy use data to be captured via the ERIC system across all NHS England organisations. This could include a requirement for sub-metering to understand consumption patterns, which is important given the 30% increase in building energy emissions between 1998-2004.

    - Requiring annual travel surveys to be conducted across its operations. This would be a very useful tool in helping to compare to the National Travel Survey data, and thus provide more accurate input data

5. To help assess effective measures which deliver real and achievable carbon reductions, we recommend that a carbon scenario modelling tool is developed, which is similar in principle to that developed for DCSF.[2]

    By comparing baseline emissions (i.e. a Business-As-Usual emissions scenario) to 2020 against a desired reduction trajectory, the effect of policies in the strategy can be examined. The quantification of the effect of policies in terms of carbon reduction potential will be a powerful tool in the NHS strategy.

6. NHS England should work to develop a bottom-up carbon measurement tool, which will enable NHS Trusts and organisations to understand their own carbon footprint, including travel, procurement and building energy emissions, and then develop carbon management techniques to reduce these emissions.

[2] *Saving Carbon, Improving Health* A draft carbon reduction strategy for the NHS in England. NHS England (2008) www.sdu.nhs.uk

1. Introduction

The NHS has produced an NHS England Carbon Reduction Strategy,[3] for consultation, as part of a broader sustainable development agenda. To support and inform this process, the NHS Sustainable Development Unit (SDU) commissioned the Sustainable Development Commission (SDC) to complete a carbon footprinting study, covering all NHS England activities. This research project has been undertaken in conjunction with the Stockholm Environment Institute (SEI).

This report details a carbon footprinting study completed for NHS England. It expands and supersedes the previous SDC report [4] issued in May 2008. The report summarises NHS England carbon dioxide (CO_2) emissions for the years 1992-2004 in three primary sectors (travel, building energy use and procurement) and their associated sub-sectors. Appendix A lists the organisations that form NHS England.

The overall aim of this report is to help prioritise key action areas in the NHS England Carbon Reduction Strategy, and to provide an evidence base for future NHS England carbon management.

The key headlines from the carbon footprinting work are:

- The NHS carbon footprint in 2004 was 18.6 million tonnes of carbon dioxide ($MtCO_2$), which represents 25% of English public sector emissions

- Overall, NHS England total consumption emissions rose by 12% between 1992-2004. Within this period, emissions fell by 5% from 1992-1998, and then rose by 18% from 1998-2004, representing a 3% rise/year in the latter period

- Embodied emissions in the manufacture and transportation of purchased goods and services account for over half (60%) of the emissions attributable to NHS England

- Emissions from procurement of pharmaceuticals make up a fifth of the total for NHS England, and are comparable to emissions from either building energy use or travel sectors

- There are significant differences between in the carbon intensities ($MtCO_2$/£) of pharmaceutical and medical equipment products according to world region of production.

- Only 26% of NHS carbon emissions would be classified as scope 1 (direct) or scope 2 (indirect - electricity) emissions under the GHG protocol definitions, with the majority (74%) being scope 3 (other indirect) emissions.

[3] *Saving Carbon, Improving Health* – A draft carbon reduction strategy for the NHS in England. NHS England (2008) www.sdu.nhs.uk

[4] *NHS England carbon emissions: carbon footprinting report* – May 2008. SDC (2008)

2. NHS England carbon footprinting methodology

2.1 Overview

The footprinting technique used in this report calculates carbon emissions based on expenditure data (from national level supply-and-use tables) and industrial sector emissions factors (from national environmental accounts data). It is thus a top-down analysis. Travel emissions calculated from National Travel Survey (NTS) data are added to the resultant footprint.

The three main sectors which form the total footprint are:

- Travel: Movement of people (i.e. patients, visitors and staff)
- Building energy use: Heating and cooling, hot water and electricity consumption
- Procurement: Embodied emissions associated with the manufacture and transportation of goods and services purchased by NHS England

A full account of the analytical footprinting methodology and data sources used is given in Appendix B.

The carbon footprint analysis calculates emissions for the period 1992-2004, since that is the range of years for which full datasets can be obtained.

2.2 Emissions terminology

The Kyoto Protocol, the core of worldwide efforts to mitigate climate change by reducing greenhouse gas (GHG) emissions, includes six GHGs in its targets.[5] The key man-made GHG is carbon dioxide (CO_2), which is released in to the atmosphere when fossil fuels (gas, oil or coal) are burned.

CO_2 and GHG[6] emissions attributable to NHS England in 2004 are given in Tables 1 and 3 below.

CO_2 emissions in 2004 account for over 85% of NHS England GHG emissions, which is comparable to the CO_2 proportion from all UK emissions.

Tables 1 and 3 also show the fraction of CO_2 versus GHG emissions remains uniform between sectors/sub-sectors. The minor exceptions are in waste and food procurement, which have increased GHG emissions due to production / degradation of organic material.

Due to this high and consistent CO_2 fraction across all sectors, only CO_2 emissions are reported in subsequent results after Tables 1 and 3.

2.3 Consumption vs production emissions

NHS England emissions are estimated on a consumption basis, and are the sum of emissions from travel, building energy and procurement sectors. Procurement emissions can be defined as the embodied emissions associated with the production, consumption and disposal of all goods and services purchased by NHS England. As goods may originate either in the UK or overseas, NHS England consumption has a global reach beyond the boundary of either England or the UK.

Regarding UK emissions, until recently only UK production emissions were known i.e. all emissions produced within the geographical UK boundary. However, a report published by Defra in 2008 determined the UK's consumption emissions to be 762MtCO_2.[7] This allows

[5] The six Kyoto greenhouse gases are carbon dioxide (CO_2), methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride.

[6] Greenhouse gas emissions are measured in equivalent units of carbon dioxide (CO_2e)

[7] Wiedmann, T., Wood, R., Lenzen, M., Minx, J., Guan, D. and Barrett, J. (2008) *Development of an Embedded Carbon Emissions Indicator – Producing a Time Series of Input-Output Tables and Embedded Carbon Dioxide Emissions for the UK by Using a MRIO Data Optimisation System,* Report to the UK Department for Environment, Food and Rural Affairs by Stockholm Environment Institute at the University of York and Centre for Integrated Sustainability Analysis at the University of Sydney, June 2008. Defra, London, UK

comparison of the consumption based emissions of both NHS England and the UK.

2.4 Data accuracy

To produce meaningful and useful data, it is important that the methodology, input data and assumptions are verified. This is now described below.

The methodology used here is based on a Multi-Regional Input-Output (UK-MRIO) model. Recently, a Monte-Carlo analysis of the uncertainties in a global MRIO model was completed [8] which found the standard error to be between 3-5%, and concluded that a "MRIO model is robust enough to provide a reliable indication of CO_2 emissions embedded in UK economic activity, including trade from and to the UK". On this basis, the MRIO methodology is judged to be suitable for this study's purpose.

Beyond the methodology, taking 2004 as the reference year, the following checks have been completed on the input data used in the NHS analysis:

- Total NHS England expenditure: Appendix C details the comparison of NHS expenditure from national supply-and-use tables (estimated at £64Bn) and the recorded Government expenditure on NHS England (£69Bn[9]). This difference in expenditure was considered as not significant to require adjustment when considering the overall aims of the carbon footprinting research

- Procurement data: The basis of the procurement emissions are (a) the ONS supply-and-use tables and (b) national environmental accounts, both of which are nationally verified datasets

- Building energy data: The energy used in buildings was calculated from the I-O analysis to be 4.1MtCO_2. This compares very well with the bottom-up Estates Return Information Collection (ERIC) energy consumption of 4.2MtCO_2

- Travel data: The travel emissions for patients, staff (commuting) and visitor travel are based solely on NTS data, using estimated numbers of visitors, staff and patients. NHS business travel emissions are extracted from the I-O model and placed in the travel emissions. Given the large size of the NHS (it is the largest employer in Europe), scaling down from NTS datasets is considered reasonable.

Finally, certain assumptions from the I-O data analysis are made, and these are included in the expenditure review in Appendix C. Firstly, expenditure (and associated emissions) used in the analysis is based on UK Government expenditure on both health and veterinary services. For the footprinting study it has been conservatively assumed that all such expenditure in this category is NHS expenditure in the UK, as the non-NHS fraction will be small. Secondly, to obtain NHS England results from this UK data set, the UK expenditure has been multiplied by 0.833 (the fraction of England/UK population) to obtain approximate NHS England expenditure.

Overall, discrepancies in the input data and methodology are not considered to be significant. Therefore there is high confidence in the general level of accuracy of the estimated NHS England emissions. Whilst minor corrections could be made to the 2004 analysis, the advantage of maintaining a consistent modelling approach is that the results are repeatable and comparable for previous and future years. This makes it a powerful tool in understanding emissions trends, as seen later in section 4 of this report.

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[6] Wiedmann, T., Lenzen, M. and Wood, R. (2008) *Uncertainty Analysis of the UK-MRIO Model – Results from a Monte-Carlo Analysis of the UK Multi-Region Input-Output Model (Embedded Emissions Indicator)*; Report to the UK Department for Environment, Food and Rural Affairs by Stockholm Environment Institute at the University of York and Centre for Integrated Sustainability Analysis at the University of Sydney. Defra, London, UK

[9] *p.31 Department of Health - Departmental Report 2006* Department of Health (2006)

3. NHS England carbon footprinting results (2004)

3.1 Total/primary sectors

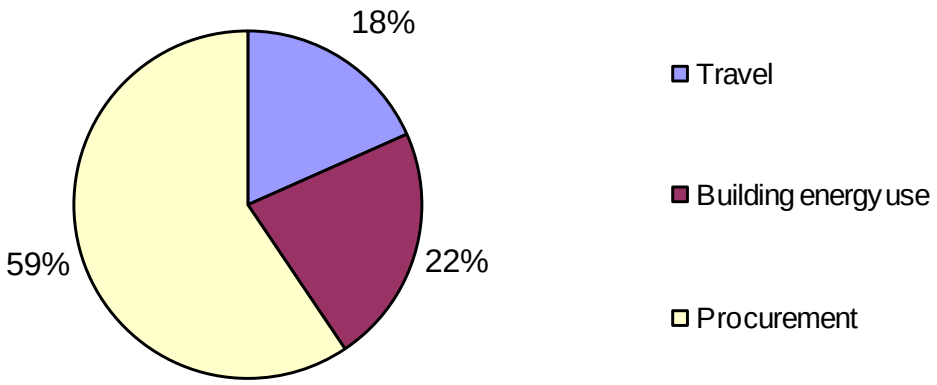
3.1.1 Key analytical results

Total NHS England emissions comprise the sum of emissions from three primary sectors: travel, building energy use and procurement. The estimated emissions in 2004 for these primary sectors and the overall total are given below in Table 1 and Figure 1:

Table 1 – 2004 CO_2/GHG emissions: primary sector breakdown

Sector	CO_2 emissions		GHG (CO_2e) emissions	
	$MtCO_2$	% of total	$MtCO_2e$	% of total
Travel	3.41	18%	3.45	16%
Building energy use	4.14	22%	4.59	22%
Procurement	11.07	59%	13.24	62%
Total	**18.61**	**100%**	**21.28**	**100%**

Figure 1 - 2004 CO_2 emissions: primary sector breakdown



3.1.2 Discussion

The total 2004 NHS England CO_2 emissions were estimated to be 18.61MtCO_2.

Procurement emissions provide 60% of overall emissions, which is a level three times higher than the 20% emissions from building energy sector. This demonstrates that NHS England's emissions profile is typical more of a service sector industry, rather than a manufacturing industry, where emissions from building energy are usually 70-80% (e.g. see the pharmaceutical and medical equipment breakdowns in Section 3.3).

It is useful to set NHS England emissions in context. From the data in Appendix B1.5, NHS England emissions in 2004 were equal to:

- 2.6% of total UK consumption emissions
- 25% of England's public sector emissions
- Almost 100% of the consumption emissions for the whole of Northern Ireland

In addition, Table 2 below finds the carbon intensity of expenditure (quoted in kgCO_2 / £ spent) for NHS England to be comparable with those from other public sectors:

Table 2 Comparative emissions/expenditure data

Category	Consumption CO_2 emissions (MtCO_2)	Net expenditure (ie gross – staff costs) (£BN)	Carbon intensity [Emissions / expenditure] (kgCO_2 / £ spent)
NHS England (2004)	**15.94**[a]	**£29.82**[b]	**0.53**
UK Public sector (2001)	75[c]	£120[d]	0.63
England Public sector (2001)	63[c]	£100[e]	0.63
DCSF schools (2004)	7.70[f]	£17.3	0.45

a. 18.61-2.67(staff commute/patient/visitor travel). This is to compare to other sectors on an expenditure basis.
b. From ONS data: 2004 Government expenditure on health £76499 million, Expenditure on employees referred to as 'staff compensation' in the IO table £41073 million. England/UK population = 0.833 (50M/60M), thus 0.833x(76.5-41.1)=£29.82BN
c. Source: Appendix B1.5
d. From ONS data: UK government expenditure £250708 million, expenditure on employees £130777 million, thus 251-131 = £120BN
e. England/ UK population = 0.833, thus 120*0.833 = £100BN
f. 8.51MtCO_2 - 0.81MtCO_2(staff commute/pupil travel): Data obtained from SDC (2008).[10]

Procurement as noted above is the largest emissions sector of NHS England, but this is proportionate to its expenditure as shown thus:

- 69%: the proportion of NHS expenditure on procurement (11.07MtCO_2/15.94MtCO_2),
- 73%: procurement's proportion of NHS consumption expenditure (£22BN / £29.8BN)

Travel and building energy use sectors each provide approximately 20% to the total estimated NHS England CO_2 emissions.

The main input data used for the travel analysis has been obtained from NTS survey data. Travel surveys completed on NHS England sites would provide bottom up data which would be invaluable for updating the travel emissions data. Similarly, full collation of ERIC energy data over all NHS England sites would improve/confirm data accuracy.

[10] *Carbon emissions from schools: where they are and how to reduce them*, SDC (2008).

3.2 Sub-sectors (2004)

3.2.1 Key analytical results

Each of the three primary emissions sectors given above in Section 3.1 has constituent sub-sectors. The estimated emissions for these sub-sectors are given below in Table 3 and Figures 2-4:

Table 3 – CO_2/GHG emissions in 2004: sub-sector breakdown

Sector	Sub sector	CO_2 Emissions		GHG (CO_2e) emissions	
		$MtCO_2$	% of total[d]	$MtCO_2e$	% of total[d]
Travel	Patient: own travel[a]	1.53	8%	1.53	7%
	Visitor travel[a]	0.38	2%	0.38	2%
	Staff: commuting[a]	0.76	4%	0.76	4%
	NHS travel: business mileage/ fleet/Patient Travel Services (PTS)[c]	0.74	4%	0.78	4%
	Travel: sub total	**3.41**	**18%**	**3.45**	**16%**
Building energy use[b]	Electricity	2.31	12%	2.44	11%
	Heating/hot water - gas	1.66	9%	1.95	9%
	Heating/hot water – coal	0.07	0%	0.08	0%
	Heating/hot water - oil	0.09	1%	0.11	1%
	All Heating/hot water - subtotal	*1.83*	*10%*	*2.15*	*10%*
	Building energy use: sub total	**4.14**	**22%**	**4.59**	**22%**
Procurement[c]	Pharmaceuticals	4.06	22%	4.57	21%
	Medical instruments/equipment	1.66	9%	1.88	9%
	Business services	0.98	5%	1.12	5%
	Paper products	0.97	5%	1.03	5%
	NHS freight transport	0.72	4%	0.75	4%
	Other manufactured products	0.63	3%	0.69	3%
	Manufactured fuels/ chemicals/ gases	0.53	3%	0.59	3%
	Food and catering	0.39	2%	0.72	3%
	Construction	0.36	2%	0.38	2%
	Information and Communication Technologies (ICT)[e]	0.32	2%	0.36	2%
	Water and sanitation	0.13	1%	0.24	1%
	Waste products and recycling	0.10	1%	0.65	3%
	Other procurement	0.08	1%	0.26	1%
	Procurement: sub total	**11.07**	**59%**	**13.24**	**62%**
Total NHS England emissions		**18.61**	**100%**	**21.28**	**100%**

[a] patient/visitor/staff travel estimated from NTS data. NHS travel from ONS data
[b] emissions based on ONS and ERIC energy return data
[c] emissions based on ONS data
[d] Values rounded to nearest whole %
[e] This is the embodied energy of the manufacture/transportation of the ICT equipment, not the emissions from energy consumption whilst in use.

Figure 2 - 2004 CO_2 emissions: travel sub-sectors

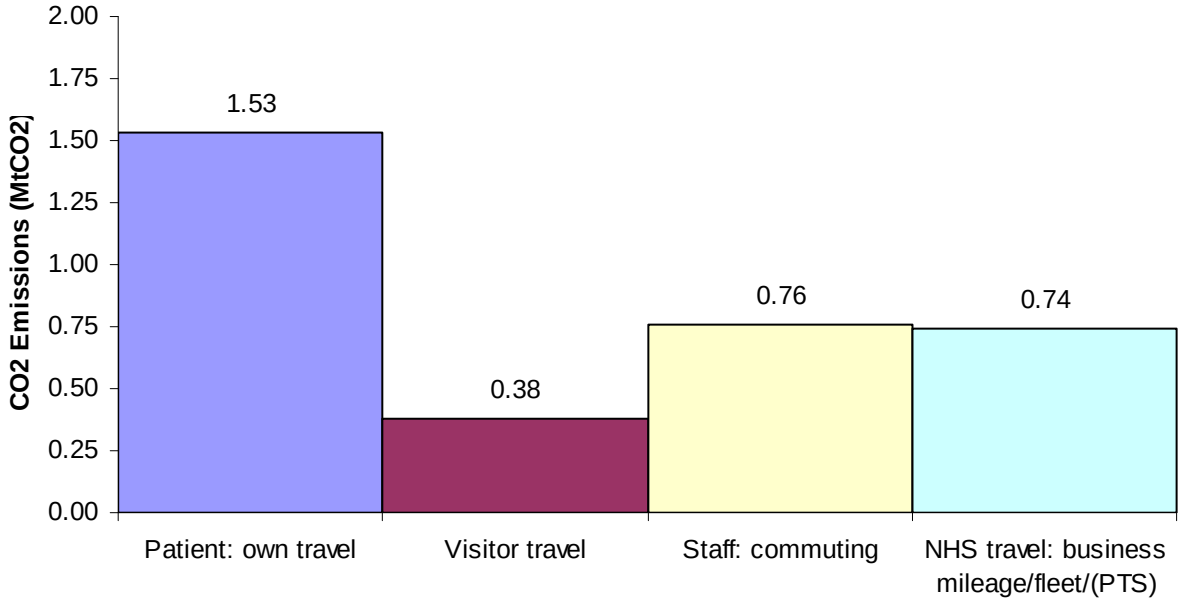


Figure 3 - 2004 CO_2 emissions: building energy sub-sectors

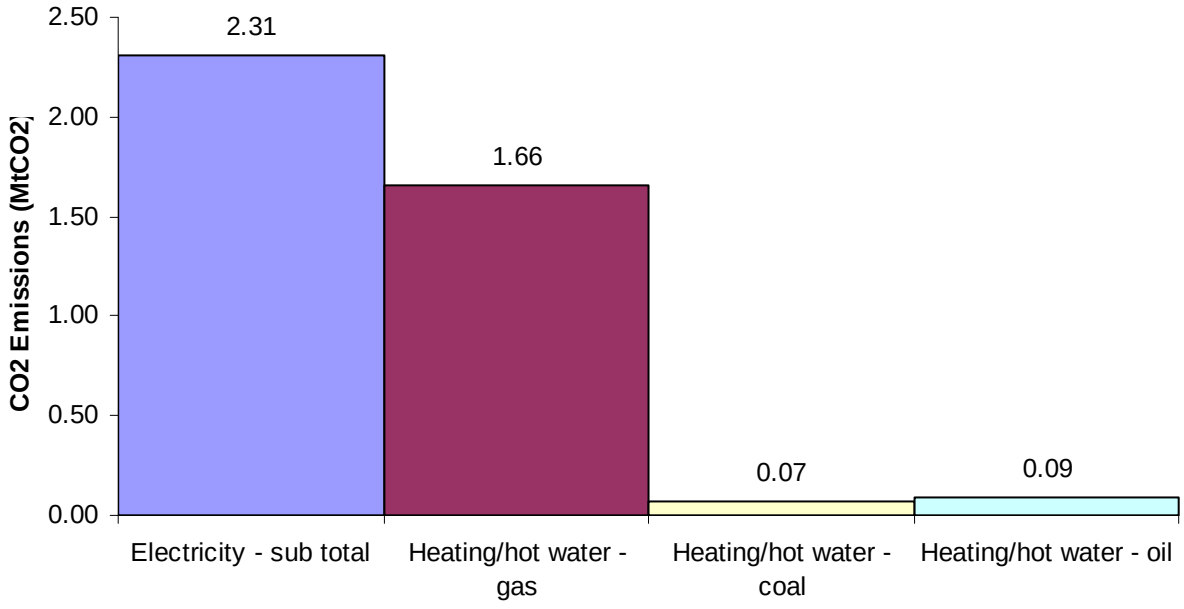
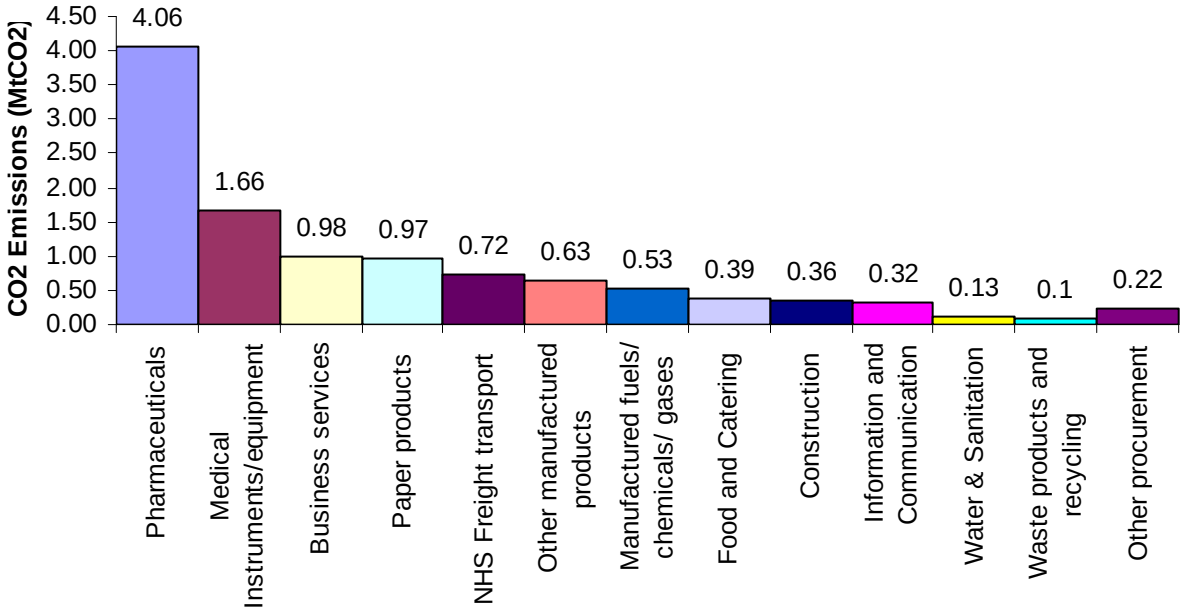


Figure 4 - 2004 CO_2 emissions: procurement sub-sectors



3.2.2 Discussion

In the travel sector, the majority (60%) of emissions are those from patients/visitors, with NHS travel (e.g. commuting, business and Patient Travel Services travel) accounting for the remaining 40% of travel emissions. We define 'travel' as the movement of people, and 'transport' as movement of goods and services. In our analysis, transport emissions from goods and services are contained within their sub-sector procurement emissions.

Electricity makes up 55% of overall emissions in the building energy sector, with on-site emissions from heating/hot water consumption forming the other 45%. Gas use is estimated to cause 90% of heating/hot water sub-sector emissions.

Breaking down energy consumption further is not possible from this top-down analysis, nor is it possible from the bottom-up ERIC data, which collates only overall electricity and on-site fossil fuel consumption data. A programme of sub-metering in NHS England buildings would improve the evidence base, by determining the separate emissions from lighting, IT, heating, hot water etc. This would build on work done by the Building Research Establishment (BRE).[11]

Pharmaceuticals and medical equipment emissions comprise over half of all procurement emissions. Pharmaceuticals were estimated to provide 37% of the procurement sector emissions, which is similar in size to either the travel or building energy sectors. Pharmaceuticals in 2004 were estimated to cost the NHS across the UK £10BN.[12] From this it can be seen that pharmaceuticals comprise 38% of procurement expenditure (£10BN* 0.833 / £22BN = 38%), which is very similar to its proportion of procurement emissions.

[11] eg. BR442 - *Carbon emissions from new non-domestic buildings: 2020 and beyond*. BRE, 2002

[12] Figure 4.14 *OHE Compendium of Health Statistics*, 2007. OHE, 2007

3.3 Breakdown of pharmaceutical and medical equipment emissions (2004)

As can be seen from section 3.2, the pharmaceutical and medical equipment sub-sectors form 50% of all procurement emissions in 2004. In order to understand more fully the origin of these emissions, further analysis was completed on these two sectors (more fully reported in Appendix B). This uses two additional techniques:

- A Structural Path analysis (SPA) based on the existing SRIO model used for the main analysis, in order to derive supply chain emissions in more detail.
- A Multi-Regional Input-Output (MRIO) model to account for emissions from different world regions. This model accounts for different production efficiencies in four world regions and as a result the emissions are not comparable to the single-regional model used throughout the report (which assumes all regions have the same production efficiency).

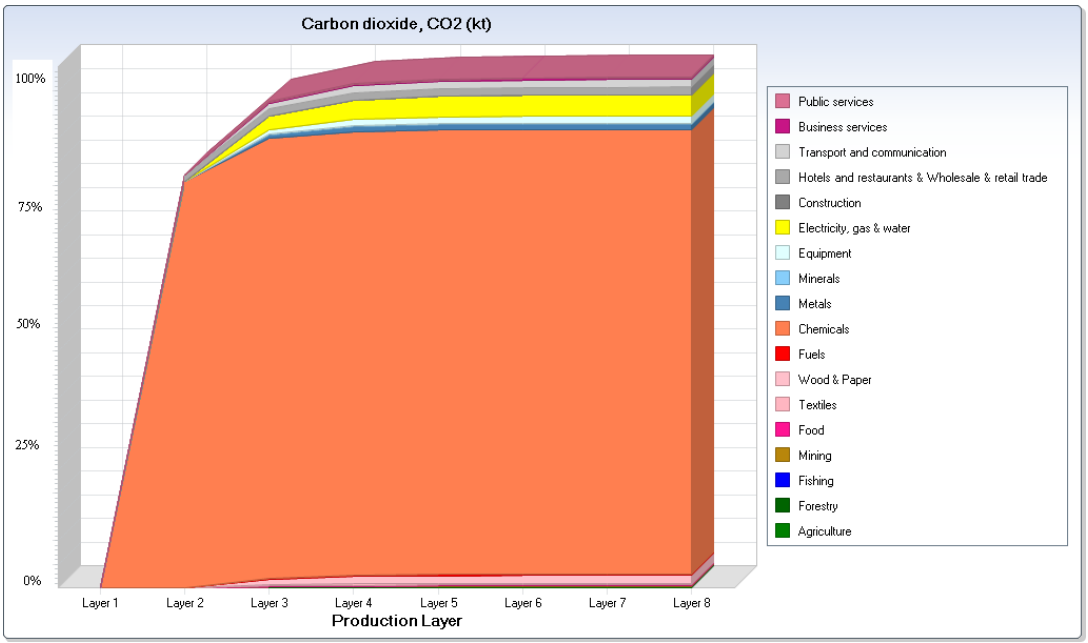
The summary results of the analysis are presented below

3.3.1 Key analytical results

(a) Pharmaceuticals

Figure 5 illustrates the pharmaceutical CO_2 emissions breakdown. This shows that 80% of emissions are directly from the pharmaceutical industry (layer 2), which are mainly due to the energy use by the factories. (Note: the sector is noted as 'chemicals' in the graph below as the results are aggregated into 18 sectors for visual display – however nearly all of this 'chemicals' sector is actually on-site pharmaceuticals energy consumption – see more detailed breakdown in Appendix B) Direct suppliers to the pharmaceutical industry (layer 3) add 12% to the carbon footprint of pharmaceuticals. These direct suppliers are from a range of industries, most notably other chemical industries, energy suppliers and the paper industry. The remaining 8% emissions are added through suppliers to suppliers of the pharmaceutical industry (layer 4) and even further up the supply chain (layer 5 onwards).

Figure 5: 2004 Pharmaceutical CO_2 emissions breakdown by production layer



Key

- Layer 1: NHS procurement of pharmaceuticals
- Layer 2: Pharmaceutical industry i.e. pharmaceutical factories

- Layer 3: Suppliers to pharmaceutical industry
- Layer 4: Suppliers to suppliers of the pharmaceutical industry
- Layer 5+: Suppliers to suppliers

Table 4 provides details about the origins of pharmaceutical products consumed by NHS England. From the expenditure and emissions data for each of the four geographic regions, the carbon intensity ($kgCO_2$/£ spent) for pharmaceutical products in each region (including embodied emissions of raw materials, production, transportation etc) can be determined.

Table 4: Pharmaceutical expenditure and carbon intensity by origin (2004)

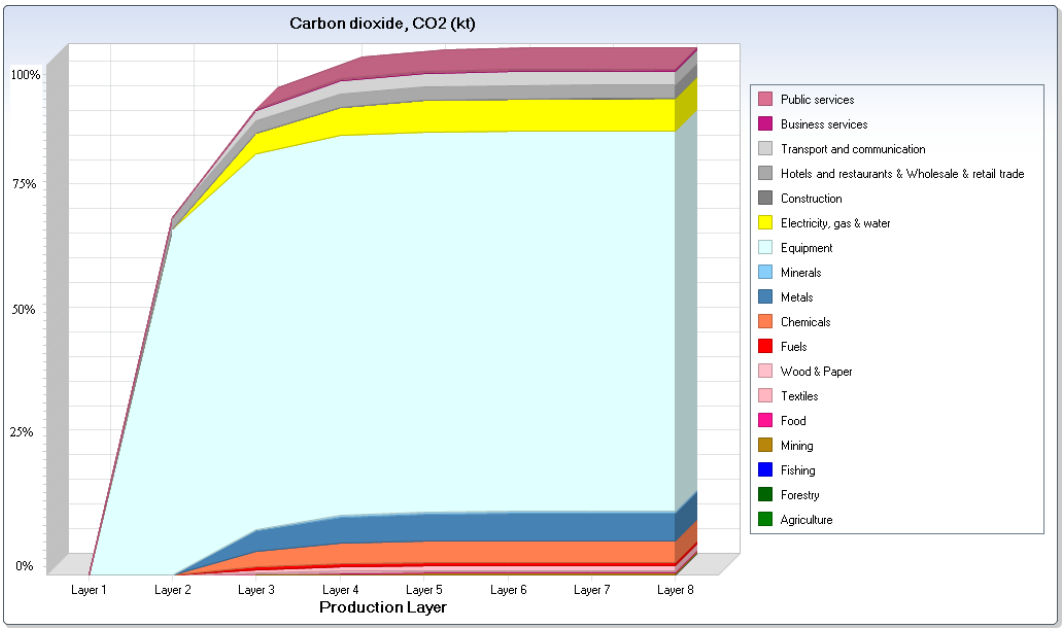
Pharmaceuticals origin (2004)	**NHS England expenditure (£Bn)**	**CO_2 emissions (Mt CO_2)**	**Carbon intensity (kg CO_2/£ spent)**
UK	1.81	0.69	0.38
OECD Europe	3.83	1.09	0.28
Non-Europe OECD	0.36	0.24	0.67
Non OECD	1.23	2.03	1.65
Total	**7.23**	**4.05**	**0.56**

(b) Medical equipment

Figure 6 shows a similar supply chain breakdown pattern is apparent from the medical instrument sector. The majority of emissions (70%) are directly from factories producing the instruments (layer 2), mainly in the form of energy consumption during the manufacturing process (Note – the same aggregation occurs here as with the pharmaceutical graph shown above. Thus nearly all of the 'equipment' emissions in layer 2 below are actually on-site emissions for the manufacture of medical equipment – see Appendix B for a more detailed breakdown). Direct suppliers to the medical instrument industry (layer 3) add 16% to the medical instruments carbon footprint, resulting from emissions embedded in materials and energy purchased by the medical instrument industry.[13] The remaining 14% of emissions are added through suppliers to suppliers of the industry (layer 4) and even further up the supply chain (layer 5 onwards).

[13] The difference in layer 2 and layer 3 emissions shows that most energy used in the manufacturing process is produced on-site (Layer 2) rather than off-site (layer 3).

Figure 6: 2004 Medical equipment CO_2 emissions breakdown by production layer



Key

- Layer 1: NHS procurement of medical equipment
- Layer 2: Medical equipment industry i.e. equipment factories
- Layer 3: Suppliers to medical equipment industry
- Layer 4: Suppliers to suppliers of the medical equipment industry
- Layer 5+: Suppliers to suppliers

Table 5 below provides details about the origins and carbon efficiency of medical products consumed by the NHS activities from the MRIO model.

Table 5: Medical equipment expenditure and carbon intensity by origin (2004)

Medical equipment origin (2004)	**NHS England expenditure (£Bn)**	**CO_2 emissions (Mt CO_2)**	**Carbon intensity (kg CO_2/£ spent)**
UK	2.04	0.75	0.37
OECD Europe	0.68	0.10	0.15
Non-Europe OECD	0.11	0.03	0.27
Non OECD	0.75	0.78	1.04
Total	**3.58**	**1.66**	**0.46**

3.3.2 Discussion

From the results outlined above, most of the emissions result from direct energy use in the manufacturing process. This is an important result, as it follows that the priority for these industries to significantly reduce emissions would be to reduce emissions from energy use in their own manufacturing processes, rather than 'external' areas such as transportation or suppliers.

In addition, Tables 4 and 5 outline firstly the geographic origins of pharmaceuticals and medical equipment procured by NHS England, and secondly that there are significant variations of carbon intensities within the four world regions in the analysis.

For pharmaceutical products, non OECD production comprises 17% of expenditure / 50% of emissions, whilst OECD production comprises 53% of expenditure / 27% of emissions.

Medical equipment has similar disparities: non OECD production comprises 21% of expenditure / 47% of emissions, whilst UK production comprises 57% of expenditure / 45% of emissions.

One caveat to these results is that the non-UK production data is subject to higher aggregation of sectors, so emissions efficiencies are subject to greater error margins. However, at a broad level, the results are sufficiently accurate for our purposes.

Overall, with procurement of medical equipment and pharmaceuticals comprising 30% of NHS England emissions, it is important that due attention is given by the NHS to reducing emissions from these procurement sectors. There are a number of ways which can be explored to achieve this, including:

- Reducing wastage of pharmaceuticals and medical equipment within the NHS (and therefore reducing unnecessary procurement emissions)
- Exploring alternatives to reduce consumption of these products, without compromising medical outcomes. For pharmaceuticals, this may mean examining prescribing regimes or alternative (less drug intensive) clinical care. For medical equipment, this could mean examining the consumption of single use items, and determining to what extent the re-use/sterilisation of such items may lower carbon emissions.
- Reviewing carbon intensity. For example, if there was a purchasing choice between two products which were similar on cost and clinical benefit, then greater importance could be placed on any differences in carbon intensity of the products.
- Working with key manufacturers to understand how best their manufacturing process can reduce carbon emissions, eg. through energy reduction or changes in energy mix. As a large purchaser, NHS England has influence and could act as a driver of change. It could for example require manufacturers to disclose their carbon accounts or carbon reduction plan, or to demonstrate that their product's carbon intensity is, say, 20% better than the sector average.

3.4 GHG Protocol: Scope 1-3 emissions

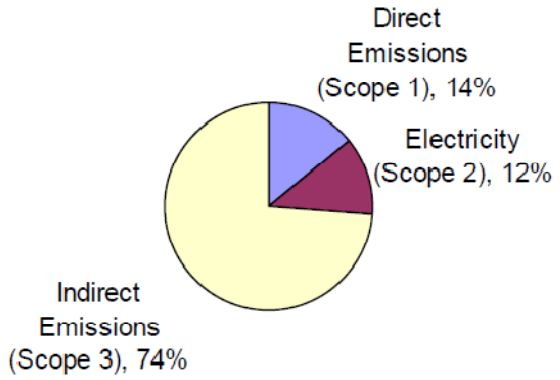
The NHS carbon footprint results can also be viewed in terms of the GHG Protocol,[14] as summarised below, and described in more detail in Appendix B - Section 3.3:

- Scope 1: Direct emissions (e.g. onsite energy production, NHS fleet travel)
- Scope 2: Electricity - indirect emissions (e.g. offsite electricity)
- Scope 3: Other indirect emissions (e.g. procurement, patient and visitor travel)

[14] Available at www.ghgprotocol.org

Accordingly the proportions of these emission categories for NHS emissions are shown below in Figure 7:

Figure 7: GHG Protocol Scope 1-3 NHS England emissions breakdown



4. Time series carbon footprinting results (1992-2004)

The time series (1992-2004) data was calculated using the same methodology as for the 2004 footprint, to ensure consistency in approach. The full results are given in Appendix B, with a summary of key results provided in this section.

4.1 Time series carbon footprinting results (1992-2004)

4.1.1 Key analytical results

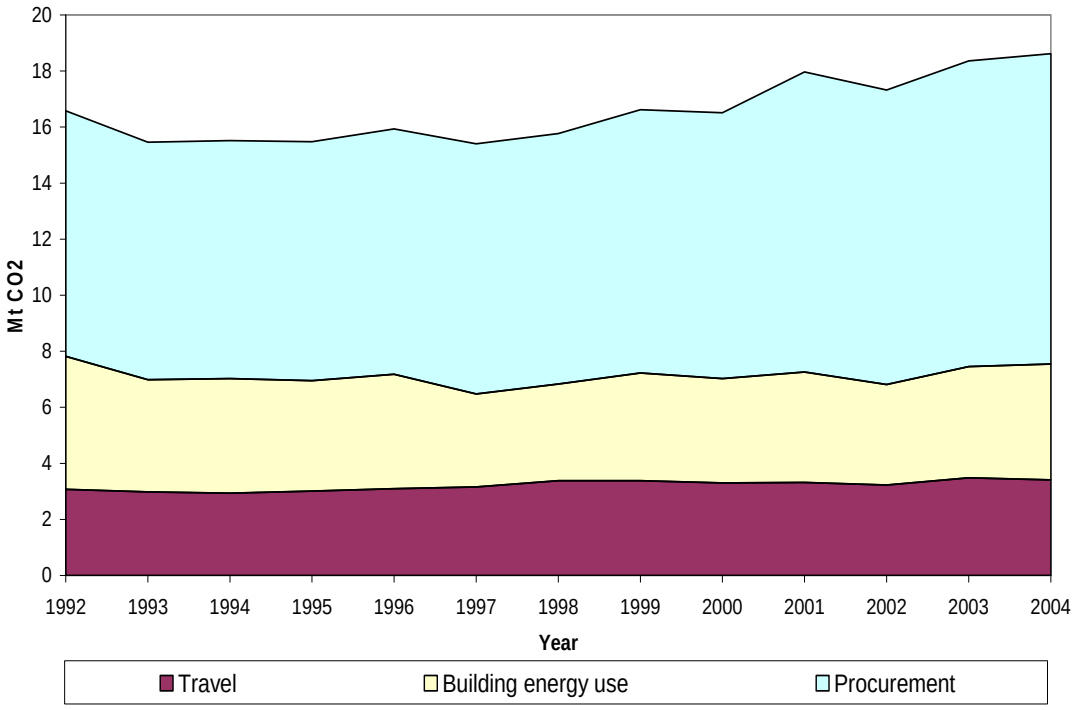
(a) Overall/total emissions

Table 6 and Figure 8 summarise the NHS England total and primary sector CO_2 emissions between 1992 and 2004.

Table 6 - Total/primary sector CO_2 emissions 1992-2004

Sector	$MtCO_2$ emissions		% change
	1992	2004	
Travel	3.07	3.41	+ 11
Building energy	4.75	4.14	- 13
Procurement	8.76	11.07	+ 26
TOTAL	**16.58**	**18.61**	**+ 12**

Figure 8: Total/primary sector CO_2 emissions 1992-2004



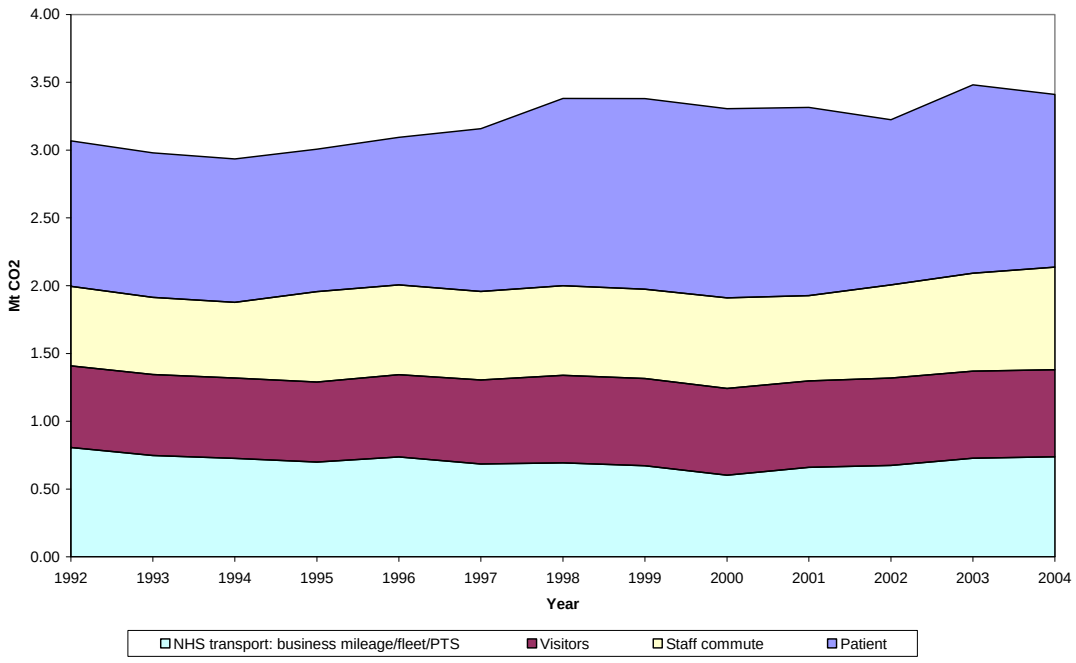
(b) Travel sector emissions

Table 7 and Figure 9 summarise the NHS England travel sector CO_2 emissions between 1992 and 2004.

Table 7 – Travel sub-sector emissions 1992-2004

Travel Sector	$MtCO_2$ emissions		% change
	1992	2004	
Patient	1.34	1.53	+ 14
Visitor	0.33	0.38	+ 15
Staff commuting	0.59	0.76	+ 29
Staff business	0.81	0.74	- 9
TOTAL	**3.07**	**3.41**	**+ 11**

Figure 9: Travel sub-sector emissions 1992-2004



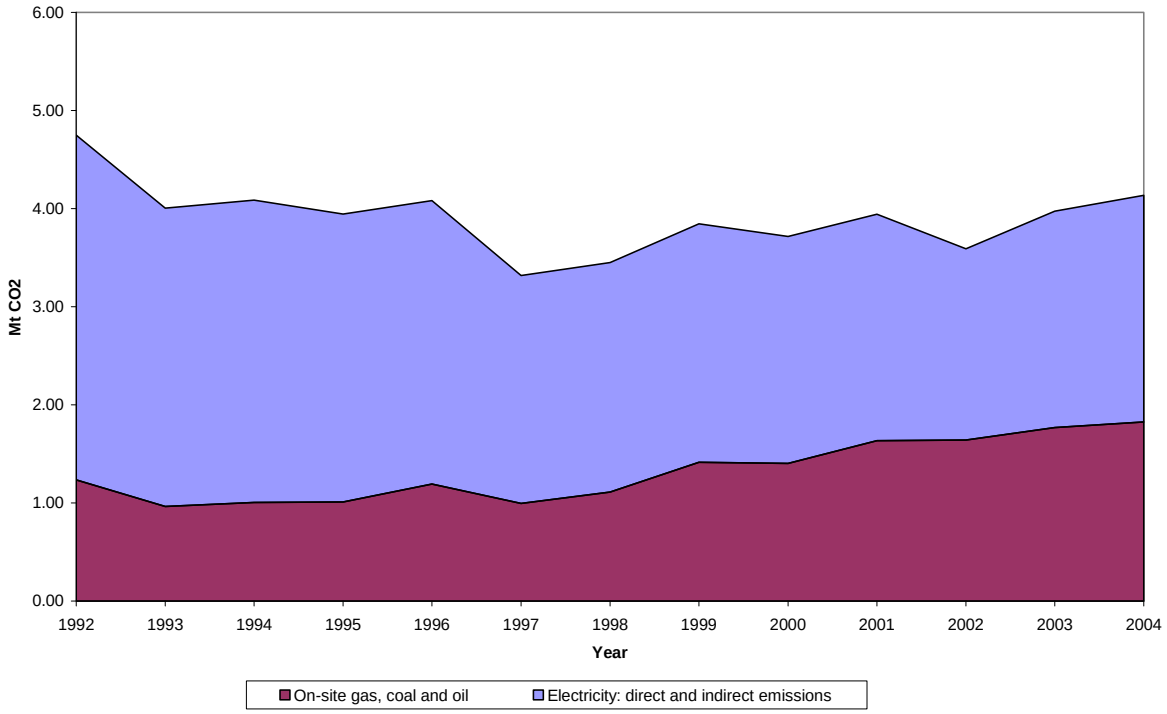
(c) Building energy sector emissions

Table 8 and Figure 10 summarise the NHS England building energy sector CO_2 emissions between 1992 and 2004.

Table 8 – Building energy sub-sector emissions 1992-2004

Building energy Sector	$MtCO_2$ emissions		% change
	1992	2004	
Electricity	3.52	2.31	- 34
On site coal, oil and gas	1.23	1.82	+ 48
TOTAL	**4.75**	**4.14**	**- 13**

Figure 10 – Building energy sub-sector emissions 1992-2004



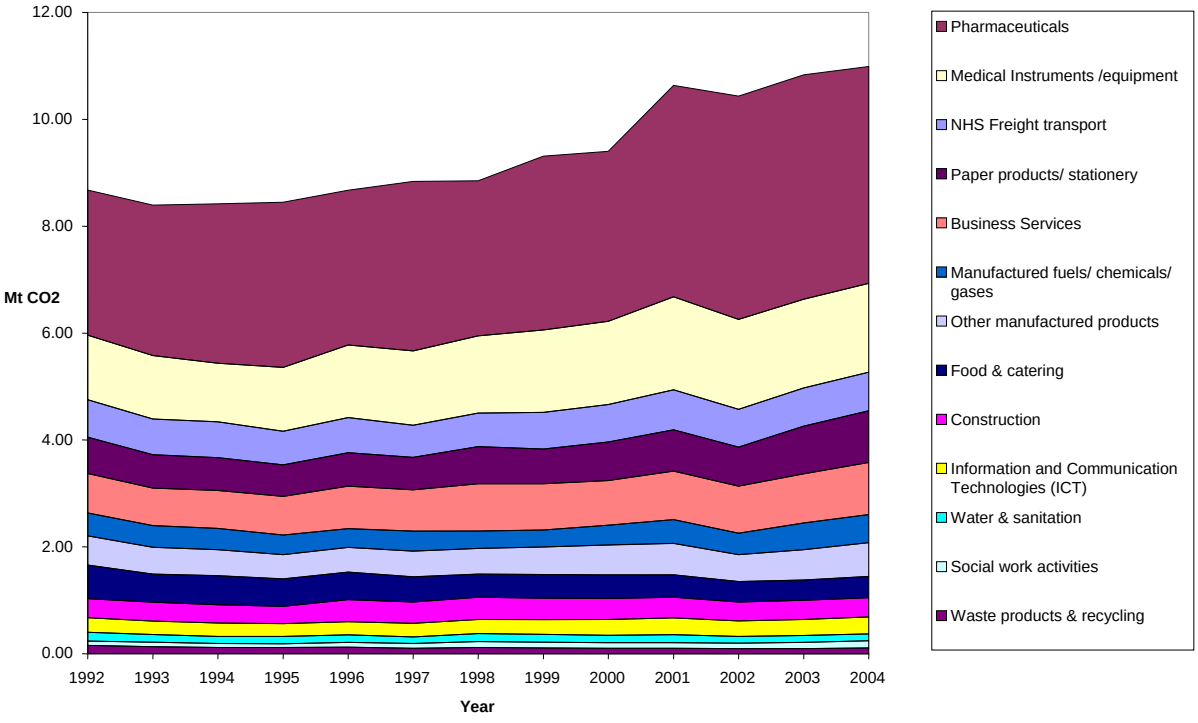
(d) Procurement sector emissions

Table 9 and Figure 11 summarise the NHS England procurement sector CO_2 emissions between 1992 and 2004.

Table 9 – Procurement sub-sector emissions 1992-2004

Procurement Sector	$MtCO_2$ emissions		% change
	1992	2004	
Pharmaceuticals	2.72	4.06	+ 49
Medical equipment	1.21	1.66	+ 37
Business services	0.74	0.98	+ 32
Paper products	0.68	0.97	+ 43
NHS freight	0.70	0.72	+ 3
Other manufactured goods	0.55	0.63	+ 15
Manufactured fuels / chemicals / gases	0.43	0.53	+ 23
Food and catering	0.62	0.39	- 37
Construction	0.36	0.36	+ 0
ICT	0.28	0.32	+ 14
Water and sanitation	0.16	0.13	- 19
Waste products and recycling	0.15	0.10	- 33
Other procurement	0.09	0.22	+ 144
TOTAL	**8.76**	**11.07**	**+26**

Figure 11 – Procurement sub-sector emissions 1992-2004



4.1.2 Discussion

The growth in total NHS consumption CO_2 emissions over 1992-2004 was 12%. This is a slightly lower (though comparable) value to the 17% rise in the same period for overall UK consumption CO_2 emissions.[15] Figure 7 shows that overall NHS England emissions reduced from 1992-1998 (-5%) and then rose from 1998-2004 (+18%).

Behind the headline 12% growth in overall NHS emissions between 1992 and 2004, Table 6 shows significant variations between the primary sectors:

- A fall in building energy emissions of 13%
- A rise in travel emissions of 11%
- A rise in procurement emissions of 26%.

Taking each sub-sector in more detail:

- The 11% growth in travel emissions is the result of an 18% rise in distance travelled, mitigated by a reduction in average vehicle emissions factors from 290g/km in 1992 to 250g/km in 2004. Table 7 outlines the largest increase in travel emissions has resulted from staff commuting (+29%), which is due in large part due to the significant rise in staff numbers over this period.

- The 13% reduction in building energy emissions is primarily due to the significant fall in electricity emissions (-34%). However, of key concern to NHS will be the data in Figure 9 which shows that from 1992-1998, building energy emissions fell by 27%, whilst emissions rose between 1998-2004 by 20%.

- Procurement emissions have a similar disparity between the emissions during 1992-1998 (+2%) and 1998-2004 (+24%), as seen in Figure 10. Significant variations within procurement sub-sector emissions over the period 1992-2004 are shown in Table 9. Whilst waste (-33%) and catering sectors (-37%) have reduced emissions, most sub-sector emissions have risen, with those associated with core NHS consumables have risen significantly during 1992-2004, including pharmaceuticals (+49%), medical equipment (+37%) and paper products (+43%).

Overall, the growth in NHS emissions over the period 1992-2004 is characterised by a fall in emissions in the first half of the period (1992-1998) followed by a sharp rise in the second period (1998-2004). A linear rise in emissions of 13% from 1992-2004 would require a cumulative increase in emissions of 1%/year. What this data shows is that emissions increased by 20% overall between 1998-2004, which equates to an average emissions rise of 3%/year.

[15] Wiedmann, T., Wood, R., Lenzen, M., Minx, J., Guan, D. and Barrett, J. (2008) *Development of an Embedded Carbon Emissions Indicator – Producing a Time Series of Input-Output Tables and Embedded Carbon Dioxide Emissions for the UK by Using a MRIO Data Optimisation System,* Report to the UK Department for Environment, Food and Rural Affairs by Stockholm Environment Institute at the University of York and Centre for Integrated Sustainability Analysis at the University of Sydney, June 2008. Defra, London, UK

4.2 Carbon intensities

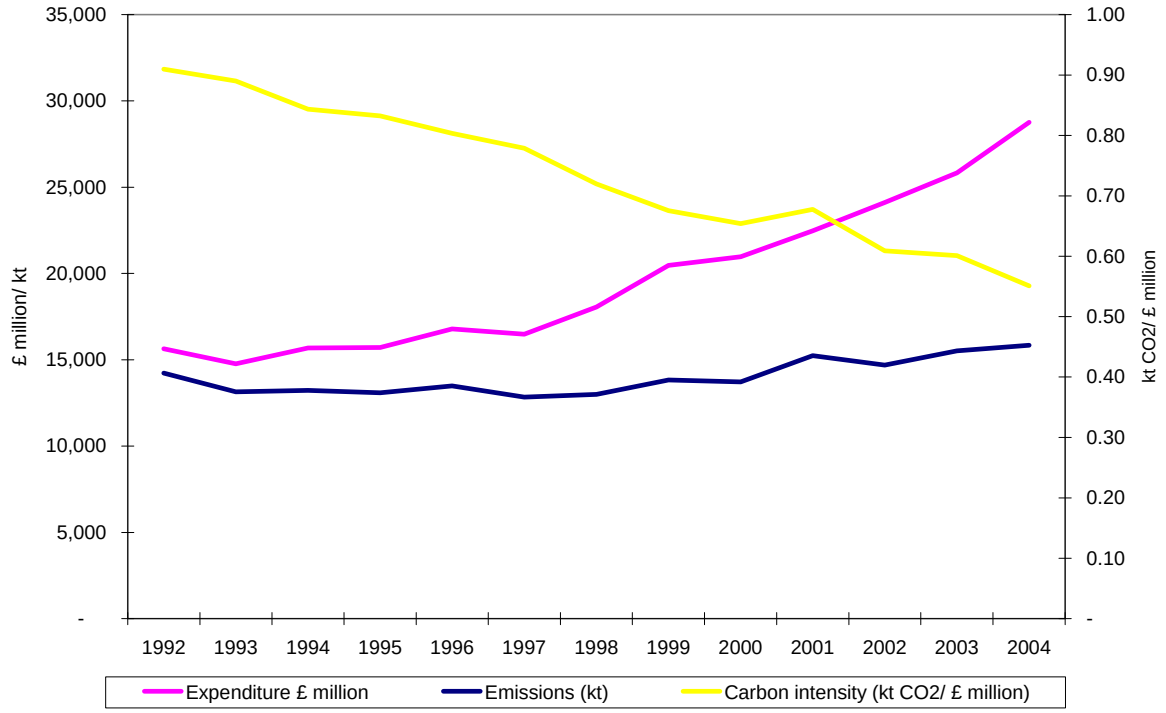
Carbon intensity can be defined as "the amount of emissions per pound spent", and can be expressed in units of $kgCO_2/£$. It includes all embodied emissions associated with the production and transportation of products to point of consumption. Carbon intensity is the reverse of carbon efficiency, in that the lower the carbon intensity, the greater the carbon efficiency. The role of carbon intensity profiles is to link expenditure to carbon emissions.

4.2.1 Key analytical results

Figures 12-16 show the expenditure, emissions and carbon intensity of NHS England consumption. The data in these graphs has been corrected for inflation, such that expenditure is at 2004 prices.

(a) Overall NHS emissions

Figure 12: Changes in expenditure, emissions and carbon intensity



(b) Building energy use and procurement emissions

Figure 13: Changes in expenditure, emissions and carbon intensity of building energy use

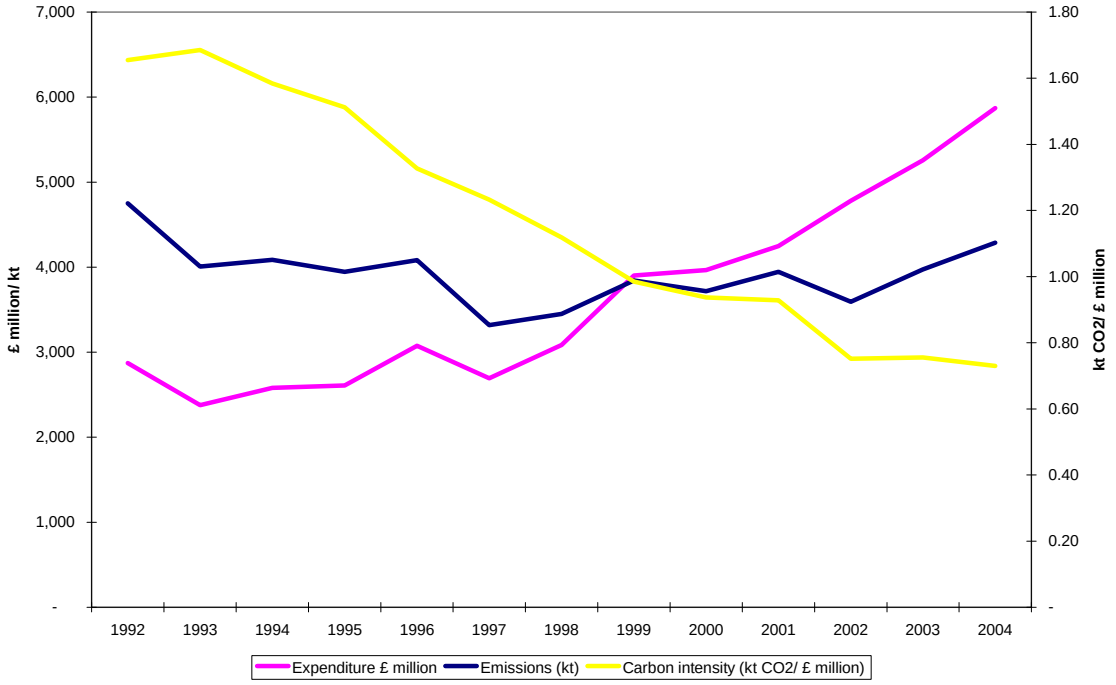
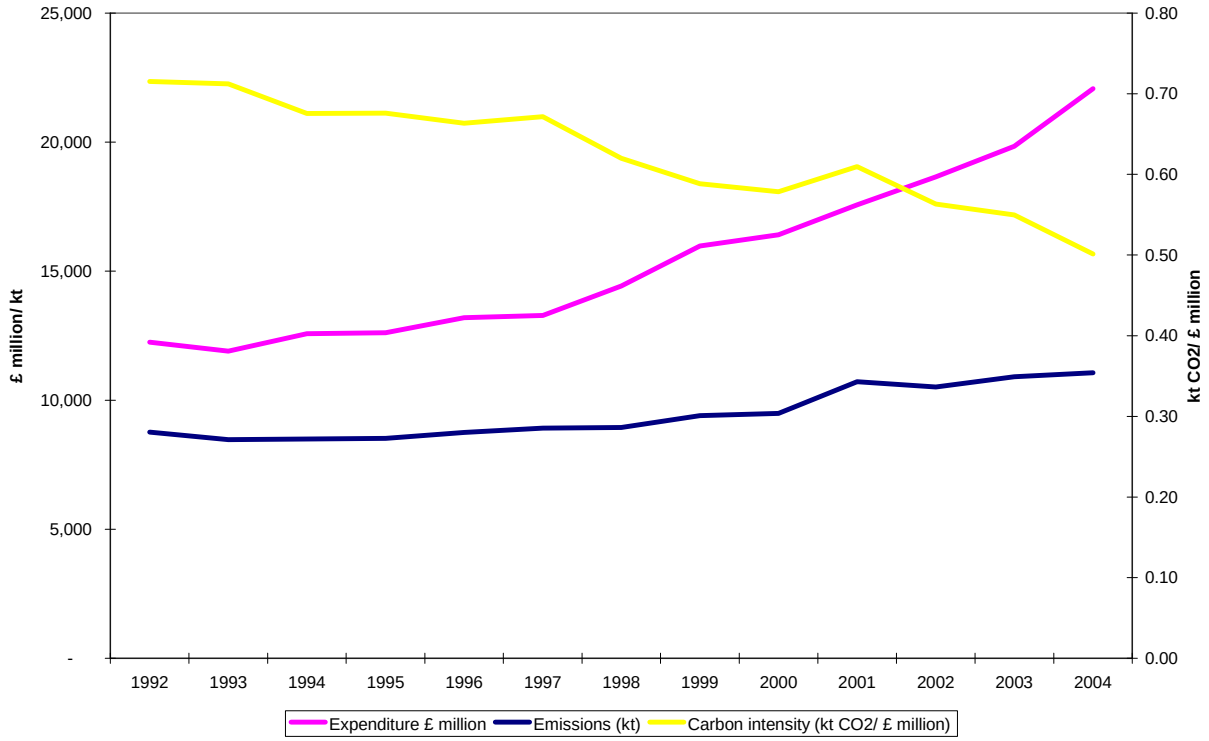


Figure 14: Changes in expenditure, emissions and carbon intensity of procurement



(c) Medical equipment and pharmaceuticals procurement emissions

Figure 15: Changes in expenditure, emissions and carbon intensity of NHS England pharmaceuticals procurement

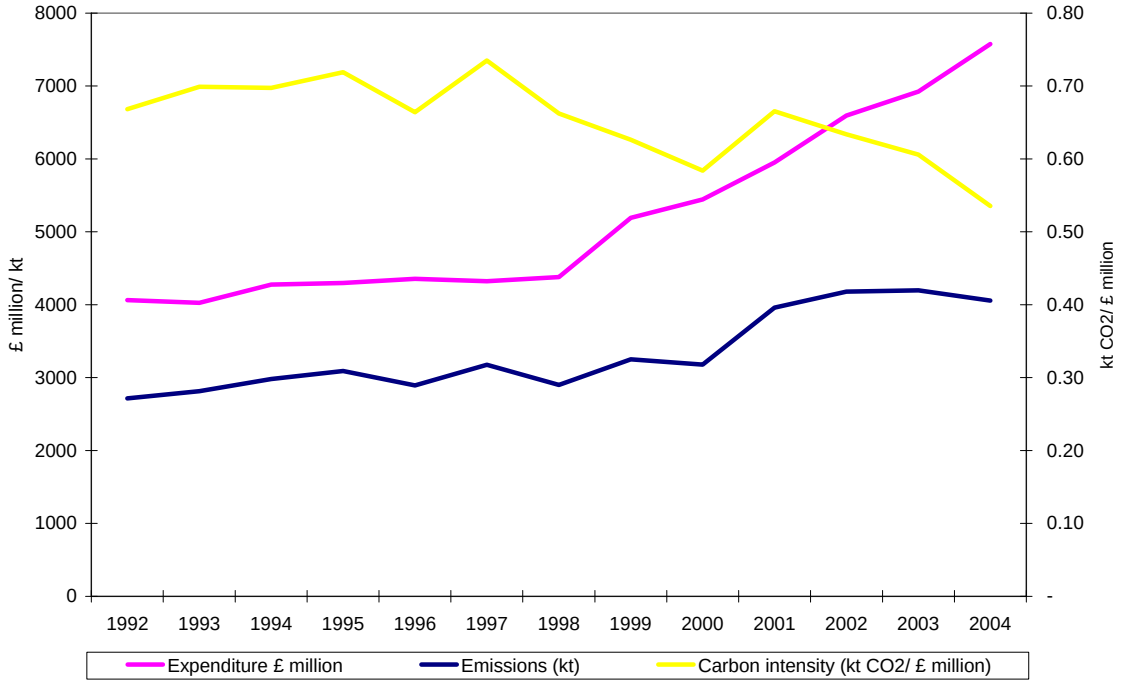
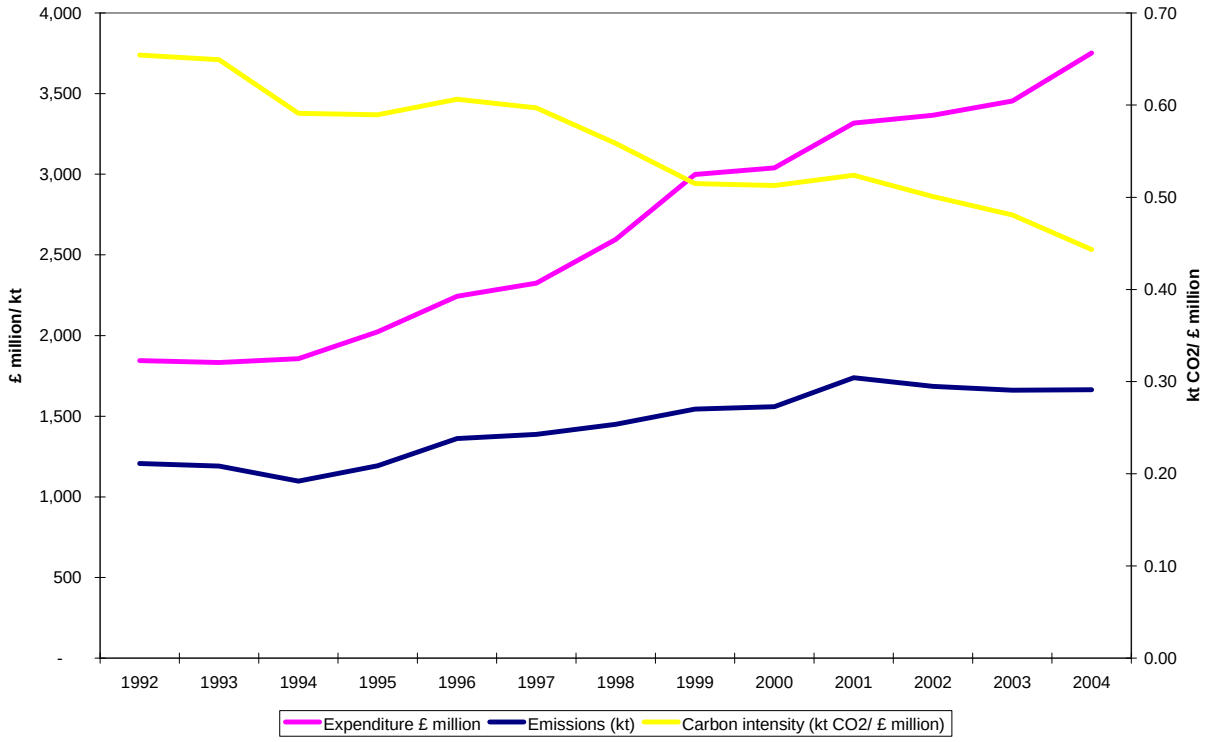


Figure 16: Change in expenditure, emissions and carbon intensity of NHS England medical equipment procurement



4.2.2 Discussion

Figure 12 shows that significant advances in production efficiency over 1992-2004 (carbon intensity has reduced by 40%, falling from 0.91 to 0.55kgCO_2/£) have failed to prevent overall NHS England consumption emissions from rising in this period. The data in Section 4.1 showed a slight reduction in emissions from 1992-1998 (-5%), followed by an 18% rise in emissions from 1998-2004. Figure 11 indicates, given a fairly constant reduction in carbon intensity over 1992-2004, the rapid increase in emissions growth is primarily due to the significant increase in NHS England expenditure that has occurred since Labour's 1997 general election win.

Figure 13 shows that the reason behind the 27% reduction in building energy emissions from 1992-1998 was a 32% decline (1.65 to 1.12kgCO_2/£) in carbon intensity, coupled with only an 8% rise in expenditure (£2.87Bn to £3.09Bn). From 1998-2004, carbon intensity continued to reduce (by 37%: 1.12 to 0.70kgCO_2/£), but expenditure levels increased by 90% (£3.09Bn to £5.87Bn), which overran the reductions in carbon intensity, leading to a 20% growth in emissions in this period.

Additionally, building energy has two important strands: electricity and heating. Appendix D gives ERIC data for 1999-2006, which shows that whilst overall energy consumption rose by 10%, this was made up of a 50% rise in electricity consumption and a 5% reduction in heating use. This indicates that electricity consumption is the key driver of building energy emissions and needs to be studied further. This trend is mirrored in many other sectors and is at least partially accounted for by the rapidly increasing penetration of ICT within buildings during this period.

Figure 14 shows how the 2% rise in procurement emissions for medical equipment from 1992-1998 was due to a combination of a 14% decline (0.72 to 0.62kgCO_2/£) in carbon intensity, and an 18% rise in expenditure (£12.25Bn to £14.43Bn). From 1998-2004, whilst carbon intensity again reduced (by 19%: 0.62 to 0.50kgCO_2/£), the increase in expenditure levels of 53% (£14.43Bn to £22.07Bn) led in this period to a 24% growth in emissions.

Figure 15 examines pharmaceutical emissions and expenditure in more detail. It shows how the carbon intensity of NHS pharmaceutical consumption reduced by 1% between 1992-1998 (0.67 to 0.66kgCO_2/£) and 18% between 1998-2004 (0.66 to 0.54kgCO_2/£). Expenditure in the same periods rose by 8% over 1992-1998 (£4.1Bn to £4.4Bn) and by 73% during 1998-2004 (£4.4Bn to £7.6Bn). The significant rise in expenditure has driven an emissions increase of 40% in the latter period 1998-2004, compared to an emissions rise of only 7% in 1992-1998.

Figure 16 shows the medical equipment expenditure, emissions and carbon intensity profiles. The graph follows a similar pattern, in that expenditure has risen faster than carbon intensity has fallen.

5. Conclusions and recommendations

The carbon footprinting analysis estimated CO_2 and GHG emissions attributable to NHS England activities, for the years 1992-2004. The contributions of the three primary sectors (travel, building energy use and procurement) have been established, together with their sub-sector emissions. Additionally, expenditure patterns have been examined to understand the carbon intensity profile over the period 1992-2004. Though some of the input data has limitations, the emissions estimated are considered to be statistically robust and valid for use in the NHS carbon reduction strategy.

There are several key conclusions which are summarised below:

1. NHS England's carbon footprint for 2004 was estimated to be 18.61 $MtCO_2$, which represents a rise of 12% over its 16.58 $MtCO_2$ emissions in 1992. Given the growth in emissions, and the fact that NHS England comprises 25% of England's public sector emissions, the NHS has a significant challenge and responsibility to reduce its emissions.

2. We can quantify potential CO_2 reduction targets for NHS England in line with those currently laid out by Government. Starting from the 1992 baseline emissions of 16.47$MtCO_2$ (compared to national emissions targets baseline year of 1990), NHS England would have to limit its emissions as follows:

    - 26-32% reduction by 2020: NHS England emissions limit = 11.20-12.20 $MtCO_2$
    - 60% reduction by 2050: NHS England emissions limit = 6.58 $MtCO_2$

3. The time series data shows the carbon footprint fell by 5% from 1992-1998, but then rose by 18% from 1998-2004. The key reason was that expenditure in this period rose much faster (+59%: £18.1Bn to £28.8Bn) than carbon intensity has fallen (-24%: 0.72 to 0.55kgCO_2/£). This resulted in a 3% per year rise in emissions in the latter period.

4. Procurement forms 60% of the emissions for which NHS England is responsible; and within the procurement sector pharmaceuticals are the largest sub-sector, making up 22% of total emissions. This is equivalent to either travel or building energy use emissions.

5. There are significant differences in the carbon intensities ($MtCO_2$/£) of both pharmaceutical and medical equipment items according to world region of production. The data suggests that though purchase of goods from non OECD countries (eg China, India) can be beneficial in economic terms, they may be less attractive on a carbon basis.

6. Only 26% of NHS carbon emissions would be classified as scope 1 or 2 emissions under the GHG protocol definitions. This shows the importance of the scope 3 emissions (as they comprise 74% of all NHS England emissions), but also highlights the importance of using the input-output methodological analysis - which uncovered these indirect emissions.

Following from the conclusions, here are our key recommendations to NHS England to take action on carbon emissions:

1. NHS England should base its carbon reduction strategy on this carbon footprinting report, and work to develop an ambitious programme of action to cut emissions.

2. NHS England should set a challenging 2020 emissions target in its carbon reduction strategy, and outline policy interventions which will have a real impact on emissions.

3. Due focus should be placed on the largest procurement sub-sectors. Examples of areas of study for the NHS could include:

    - Pharmaceuticals: Examine usage/wastage of pharmaceuticals; work with key manufacturers on lowering emissions; study the carbon intensities ($kgCO_2/£$) by world region for generic and R&D based medicines; investigate alternative models of care which may be less drug intensive.

    - Medical equipment: Investigate the breakdown of consumption by category – for example the use of single use items could be reviewed on a carbon basis.

4. Future input data to the carbon modelling work should be strengthened by:

    - Making mandatory the requirement for building energy use data to be captured via the ERIC system across all NHS England organisations. This could include a requirement for sub-metering to understand consumption patterns, which is important given the 30% increase in building energy emissions between 1998-2004.

    - Requiring annual travel surveys to be conducted across its operations. This would be a very useful tool in helping to compare to the National Travel Survey data, and thus provide more accurate input data

5. To help assess effective measures which deliver real and achievable carbon reductions, we recommend that a carbon scenario modelling tool is developed, which is similar in principle to that developed for DCSF.[16] By comparing baseline emissions (i.e. a Business-As-Usual emissions scenario) to 2020 against the desired reductions trajectory, the effect of policies in the strategy can be examined. In effect, the tool can be used to derive Pacala-Socolow[17] type emissions wedges to achieve emissions cuts. The quantification of the effect of policies in terms of carbon reduction potential will be a powerful tool in the NHS strategy.

6. NHS England should work to develop a bottom-up carbon measurement tool, which will enable NHS Trusts and organisations to understand their own carbon footprint, including travel, procurement and building energy emissions, and then develop carbon management techniques to reduce these emissions.

6. Citation and queries

This report is a joint publication by the SDC and the SEI. It has been co-funded by the NHS SDU. Please cite it as SDC (2008) *NHS England carbon emissions: carbon footprinting study – September 2008,* Sustainable Development Commission, London.

Comments or queries relating to this report should be directed to **enquiries@sd-commission.gsi.gov.uk**

[16] *Saving Carbon, Improving Health* – A draft carbon reduction strategy for the NHS in England. NHS England (2008) www.sdu.nhs.uk

[17] *Stabilization wedges: Solving the Climate Problem for the next 50 years with current technologies*, S. Pacala and R. Socolow, Science, (2004).

Appendix A – NHS England

The list below shows the current NHS England organisations:

NHS organisation	Number	Sub-organisations included
Primary Care Trusts (PCTs)	147	NHS Direct NHS Walk in centres NHS GP practices NHS dentists NHS opticians NHS pharmacists
NHS Trusts	235	NHS trusts NHS foundation trusts NHS mental health trusts NHS ambulance trusts
Care Trusts	10	
Total No of Trusts	**392**	**Trusts**
Strategic Health Authorities	10	North East SHA North West SHA Yorkshire & Humber SHA East Midlands SHA West Midlands SHA East of England SHA London SHA South East Coast SHA South Central SHA South west SHA
Special Health Authorities	10	Health Protection Agency Mental Health Act Commission National Institute For Health and Clinical Excellence National Patient Safety Agency National Treatment Agency NHS Blood and Transplant NHS Business Services Authority NHS Professionals Special Health Authority The Health and Social Care Information Centre The NHS Institute For Innovation and Improvement
Regional Directorates	5	North East Cluster North West & East Midlands Cluster Eastern Cluster Southern Cluster London Cluster
NHS England does not include	Nursing homes Charities Hospices Private Hospitals	

Appendix B – The carbon footprint of NHS England Stockholm Environment Institute, July 2008

Carbon Footprint of the National Health Service in England

Kate Scott, John Barrett, Tommy Wiedmann and Jan Minx

Stockholm Environment Institute

July 10th, 2008

Contents

Introduction

Between 1950 and 2005 there has been an unprecedented rise in global consumption. Within this timescale, timber use and grain consumption have tripled, fossil fuel consumption has quadrupled, the amount of fish caught has increased fivefold and paper use has increased six fold (FAO, 2005, FAO, 2005a, USDA, 2006, UN, 2007). While economic indicators show positive increases in investment, production and trade, the key environmental indicators illustrate increasingly negative results.

Whilst there are a range of problems associated with a number of environmental issues, there is currently a specific focus on climate change, partly due to its far reaching consequences. The political momentum to address the adverse effects of climate change through both mitigation and adaptation is mounting. At a national level the Stern Review has focused attention on the issue with the clear message that we need to act now or literally pay the price at a later stage stating that the overall costs and risks of climate change will be equivalent to losing at least 5% of global GDP per year, now and forever. More importantly, climate change potentially threatens the livelihoods of millions of vulnerable people.

With this is mind, there is clear acknowledgement that responsibility for mitigation lies with the developed countries as they all have disproportionately higher carbon emissions on a per capita basis. The UK has a legally binding commitment under the Kyoto protocol to reduce greenhouse gas emissions (GHG) by 12.5% below base-year level (1990), over the first commitment period 2008-2012. The UK also has a domestic target to reduce carbon dioxide emissions by 20% below 1990 levels by 2010 and the Energy White Paper sets a longer term goal of reducing carbon dioxide emissions by 60% by 2050 with real progress to be achieved by 2020. There is also further discussion that suggests the required reduction is nearer 80% to avoid some of the more extreme effects of climate change. There is also a case for moving early, i.e. achieving a reduction sooner rather than later.

Bearing in mind the scale of change required, not one organisation or even individual can carry on as “business as usual”. The scale of change is significant. Every organisation needs to both improve in efficiency as well as change consumption patterns to achieve the required reduction.

UK Carbon Dioxide Emissions and Indicators

UK Carbon Dioxide Emissions

In accordance with the Kyoto Protocol, UK emissions are based on a territorial CO_2 accounting framework which excludes import-related emissions due to consumption. In addition to this, emissions related to aviation and shipping are also excluded. With this in mind, the UK has reduced its Kyoto-related emissions by 5% between 1992 and 2004, an average annual reduction of 0.4%. To achieve the necessary reduction in emissions, an annual reduction of 3% is required from 2004 – 2010.

When emissions related to aviation and shipping are added (described as Environmental Accounts in figure 1), the UK's carbon footprint has increased by nearly 2% over the same time period.

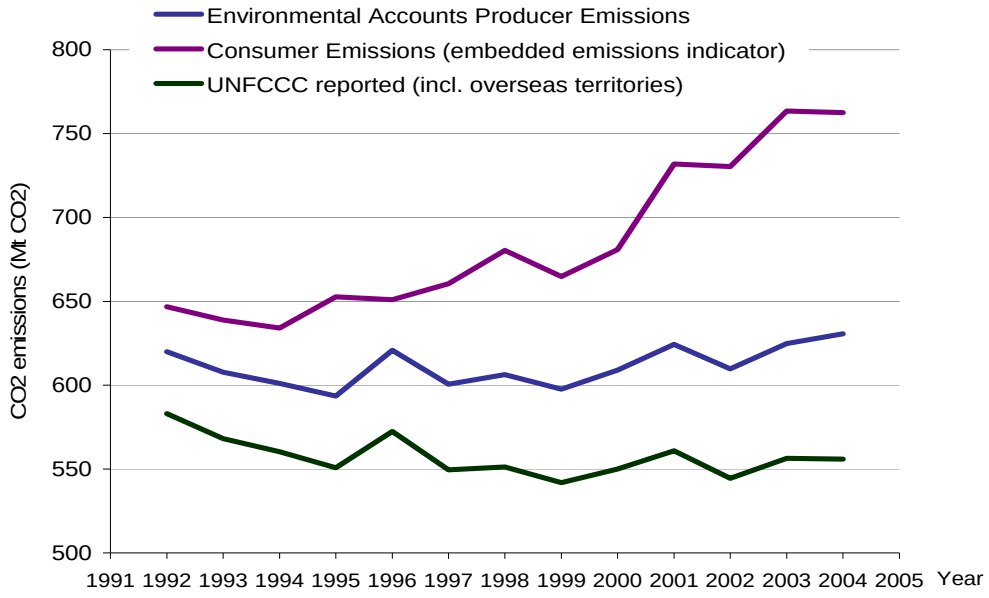


Figure 1: UK Carbon Dioxide Emissions (1992 to 2004) [18]

However, the picture changes considerably when a "consumer emissions" perspective is adopted. This includes the emissions from goods and services imported into the UK and consumed in the UK. The accounts subtract the emissions associated with exports (unless they are imported again). From this perspective, the carbon footprint of the UK has increased by 18%. This has serious consequences in terms of measuring real progress to achieving a low carbon economy.

[18] Taken from 'Development of an Embedded Carbon Emissions Indicator' by SEI and the University of Sydney available at http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=14606#RelatedDocuments).

Carbon Footprint of Organisations

In terms of the NHS, the key issue relates to what is included in the analysis and what is excluded. If we were to merely include the "territorial" or "direct" emissions of the NHS, then a significant proportion of its impact would be excluded from the analysis.

This carbon footprint includes both direct (on-site) as well as indirect (from suppliers and other sectors in the economy) emissions of carbon dioxide and other Greenhouse Gases (GHG). It is a relatively easy to calculate direct emissions. A set of standard co-efficients has been published by Defra taken from the International Panel on Climate Change (IPCC). These co-efficients convert the total use of gas, oil, petrol and other fuels into the associated GHG emissions. Therefore, for a company to understand their direct impacts the only information required is the total energy use and mileage travelled by company cars.

There are considerably more methodological difficulties when estimating indirect emissions. So, why is it important to include these indirect emissions? As organisations continue to outsource their operations it is difficult in some cases to see where NHS emissions begin and end. This increase in specialisation in almost all markets means that supply chains are endless. An ideal accounting system must trace all the interactions that take place to produce a product or service purchased by the NHS. This would be a boundary free system. This approach starts by acknowledging that every company or organisation is merely part of an "integral chain" that we call the economy. No organisation works in isolation and to account for its direct impacts only will always provide an underestimate of the costs and benefits associated with its actions.

The methodology employed in this study does exactly that; takes into account all the indirect emissions of a company. The methodological approach used is an Environmental Input-Output Analysis (EIOA). A more detailed approach of the methodology can be found in the **Appendix B1.**

Accounting for Carbon – Our Approach

The GHG Protocol Corporate Standard provides standards and guidance for companies and other organisations preparing a GHG emissions inventory[19]. Three scopes are defined for GHG accounting.

- Scope 1: Direct GHG emissions

"Direct GHG emissions occur from sources that are owned or controlled by the company, for example, emissions from combustion in owned or controlled boilers, furnaces, vehicles, etc.; emissions from chemical production in owned or controlled process equipment."

- Scope 2: Electricity indirect GHG emissions

"Scope 2 accounts for GHG emissions from the generation of purchased electricity consumed by the company. Purchased electricity is defined as electricity that is purchased or otherwise brought into the organisational boundary of the company. Scope 2 emissions physically occur at the facility where electricity is generated."

[19] Available at http://www.ghgprotocol.org/

- Scope 3: Other indirect GHG emissions

"Scope 3 is an optional reporting category that allows for the treatment of all other indirect emissions. Scope 3 emissions are a consequence of the activities of the company, but occur from sources not owned or controlled by the company. Some examples of Scope 3 activities are extraction and production of purchased materials; transportation of purchased fuels; and use of sold products and services."

All the results are shown using this recognised standard classification. In addition to this further indicators have been developed. Table 1 provides a summary of the indicators that can be found in this report.

Indicator	**Description**
"Carbon Footprint"	The carbon footprint is a measure of the exclusive total amount of carbon dioxide emissions that is directly and indirectly caused by an activity or is accumulated over the life stages of a product (Wiedmann and Minx, 2007[20])
"Carbon intensity"	Carbon Footprint / £ spent by the NHS (kg CO_2/ £)

Table 1: Indicators used in this report

[20] Wiedmann, T. and Minx, J. (2007). A definition of Carbon Footprint, ISA[UK] Research Report 07-01, available at http://www.censa.org.uk/reports.html.

Results – Carbon Footprint of the NHS England

The total baseline **carbon footprint** of NHS England was calculated for 2004. The carbon footprint includes direct (on-site) as well as indirect (from suppliers and other sectors in the economy) emissions of carbon dioxide, as described in the methodology (see Appendix B1). In this section the results have been divided by a number of different classifications. Initially, the results are displayed in a consistent format with the GHG Protocol.

The carbon footprint of NHS England is 18.6 million tonnes (Mt CO_2), equating to 2.4% of the UK's 760 Mt CO_2 total consumption based carbon footprint. Emissions from NHS expenditure (i.e. excluding travel emissions from staff commuting and patient/visitor travel) are 15.9 Mt CO_2, which is 21% of the comparable UK Government's public sector carbon footprint of 75 million tonnes.

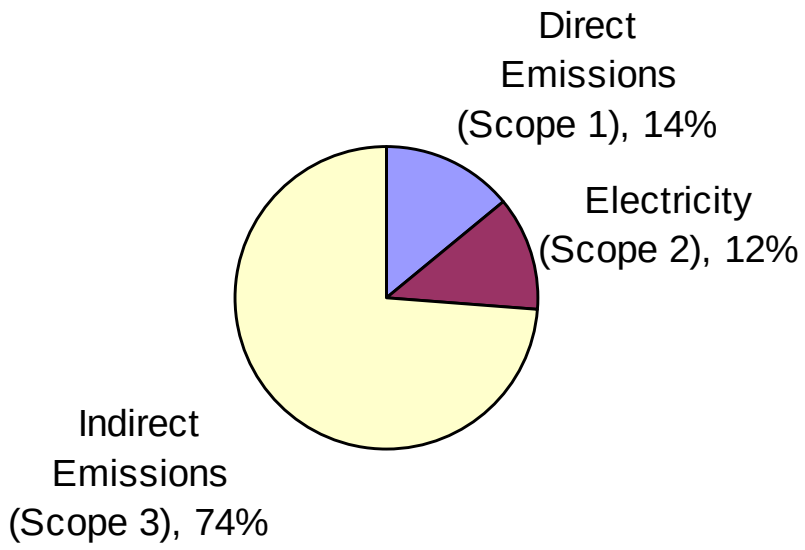


Figure 2: Carbon Footprint of NHS England (raw data table in Appendix B2.1)

Traditionally, the majority of scope 1 and 2 emissions are included in a carbon accounting assessment of an organisation or company. It is very rare for scope 3 to be included and even rarer for a complete supply chain analysis to be undertaken. However, the proportion that scope 3 emissions contribute to the total demonstrates the importance of including them in the analysis. For the NHS, scope 3 emissions represent 60% of the carbon footprint.

The inclusion of these emissions ensures that it is not possible to outsource the delivery of a key part of the NHS organisation and at the same time outsource responsibility. For example, if the NHS were to outsource all logistics then the emissions would move from scope 1 to 3. In the majority of analyses they would then be

removed from the carbon assessment, even demonstrating a reduction if comparing years. This problem would not arise in this analysis due to its completeness.

The carbon footprint can as be divided by "activity based" themes, i.e. the sum of emissions from three primary sectors: travel, building energy use and procurement.

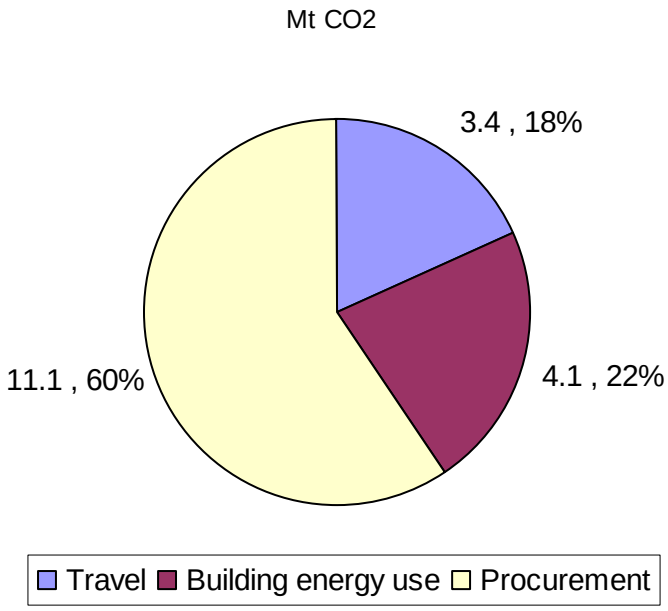


Figure 3: Primary sector breakdown of NHS England carbon footprint (Mt CO_2) (raw data table in Appendix B2.2)

As demonstrated in both figure 2 and 3, procurement is the key issue, responsible for 60% emissions, and from a breakdown of the primary sectors into sub/ secondary sectors, pharmaceuticals make up 37% of procurement emissions (22% of the total emissions). This is equivalent to emissions from NHS-related travel and energy use. Figure 4 provides a "next level down" analysis of the results, along with a table of the results in Appendix B2.3.

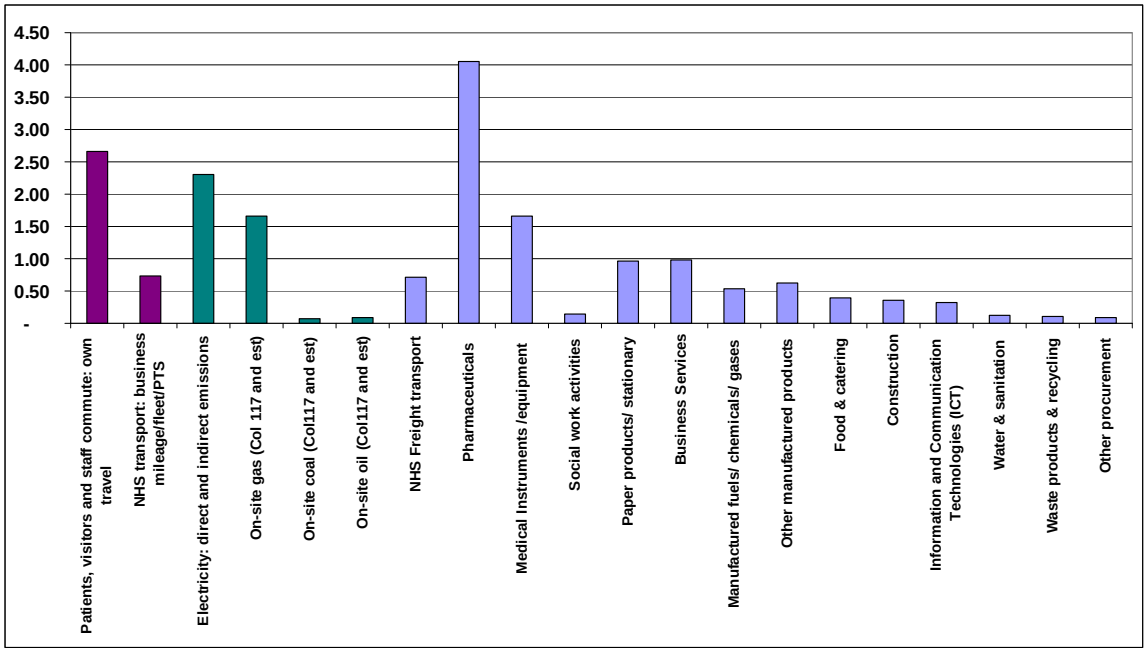


Figure 4: Secondary sector breakdown of NHS England carbon footprint (raw data table in Appendix B2.3)

From the secondary sector breakdown we can see that the biggest issue for NHS-related travel is not with NHS business mileage, but with patient travel to and from NHS premises (figure 5 below). Emissions related to electricity and gas use, which account for 2.3 and 1.7 Mt respectively, are comparable to emissions from travel (figure 6). However, a key finding of the study is the emissions related to procurement (figure 7). There are some sectors which are often perceived as important sectors, notably waste and food. However, these have a relatively low carbon impact for the NHS. Our model assigns the carbon embedded in products to the product itself and not to waste. It is emissions embedded in pharmaceuticals and medical instruments that make a significant stamp on the NHS footprint.

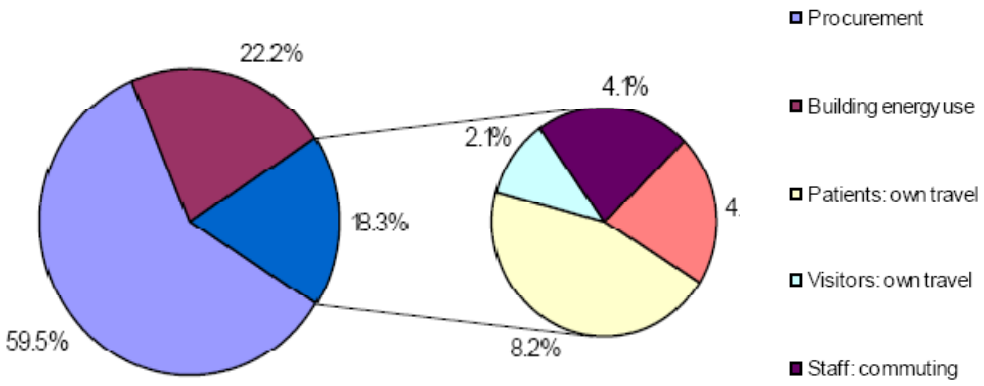


Figure 5: Travel breakdown

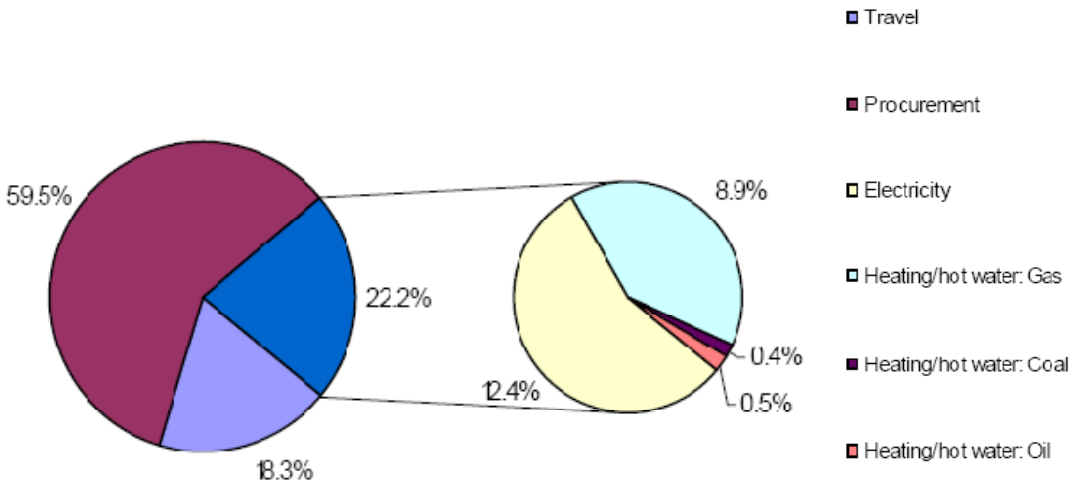


Figure 6: Building and energy breakdown

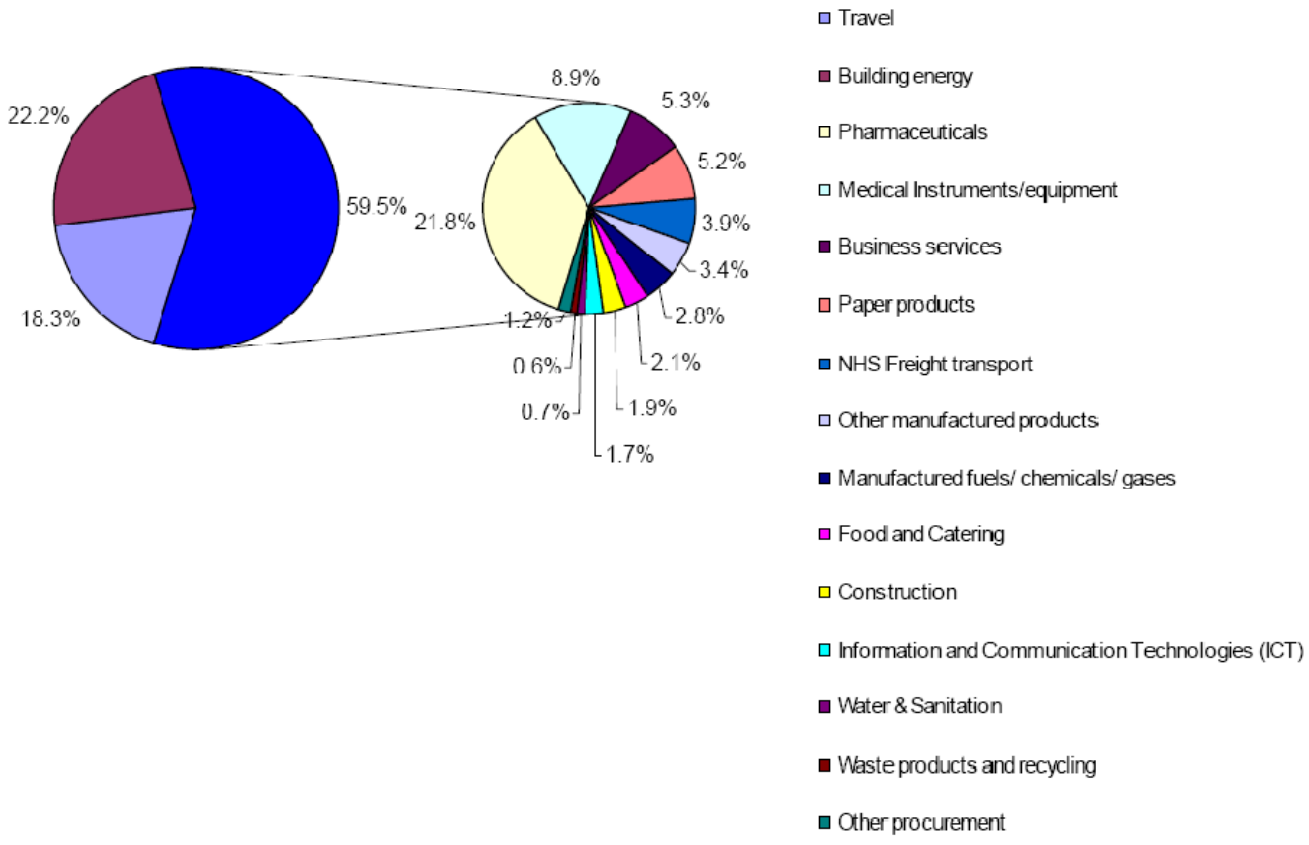


Figure 7: Procurement breakdown

Time Series Analysis of NHS England (1992 – 2004)

A time series for the NHS was carried out giving the changes in CO_2 emissions and the carbon intensity of the NHS England for 1992 to 2004. This provides an insight into the progress the NHS is making in achieving a low carbon organisation.

Total change by sectors

Overall emissions from NHS England have increased between 1992 and 2004 by 12%, rising in both NHS-related travel and procurement. However, emissions from energy use have declined over this time period (figure 8). A reduction in emissions was achieved from 1992 – 1997, yet since then emissions have been on a steady rise.

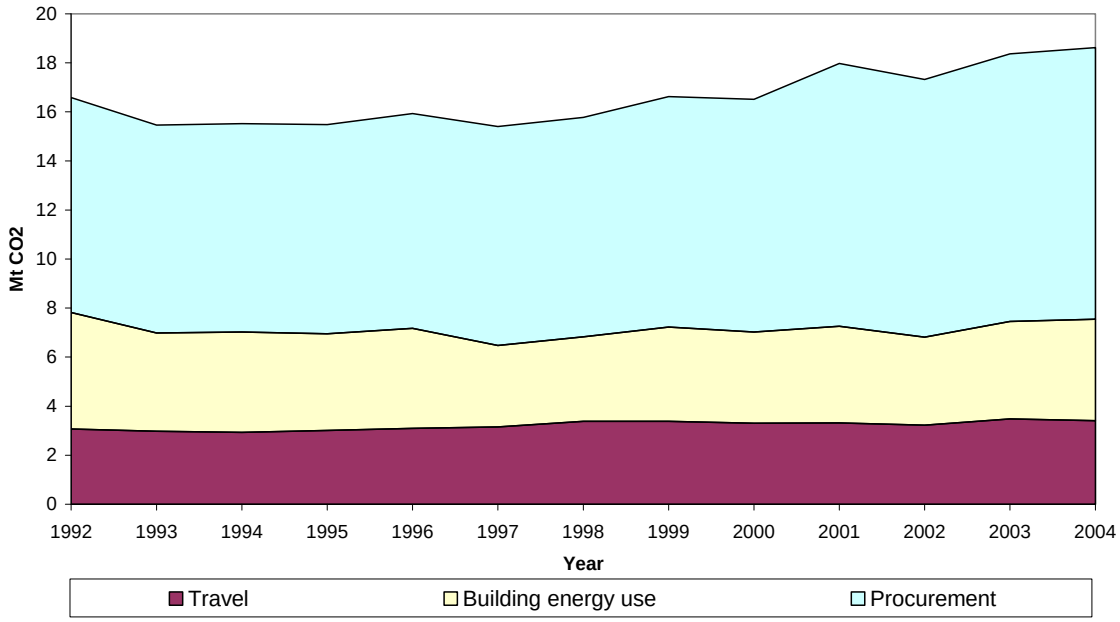


Figure 8: Total emissions over time for the three main sectors of travel, energy and procurement (raw data table in Appendix B2.4)

Change in emissions by sub-sector from 1992 to 2004

Breaking figure 8 down into the sub-sectors sectors of travel, building energy and procurement, illustrates the changes made in each sector and their contribution to the change in emissions over time (figure 9).

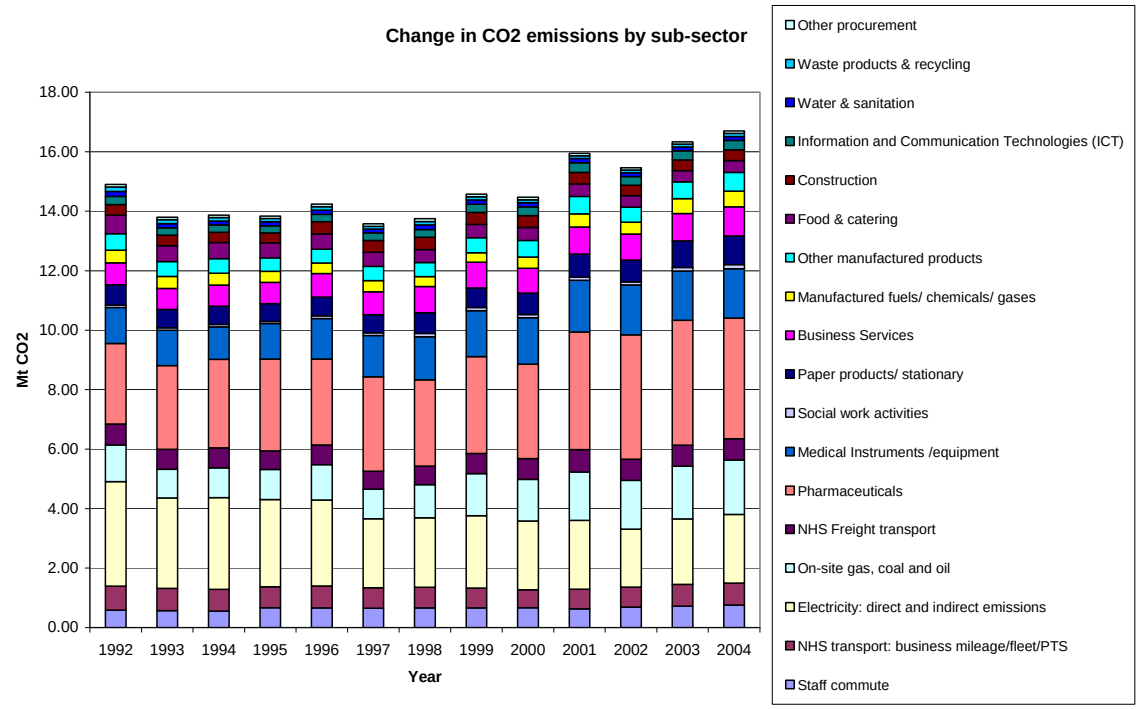


Figure 9: Emissions by sub-sector from 1992 to 2004 (raw data table in Appendix B2.5)

The rise in emissions is largely from NHS procurement of pharmaceuticals (an increase of 49% since 1992); alongside a quite significant increase in emissions from most procurement categories (figure 10). Whilst emissions from the production of electricity have gone down by 34%, emissions from on-site energy use (i.e. gas) have gone up by almost half. Emissions from staff, patient and visitor travel have increased over time (18% increase since 1992).

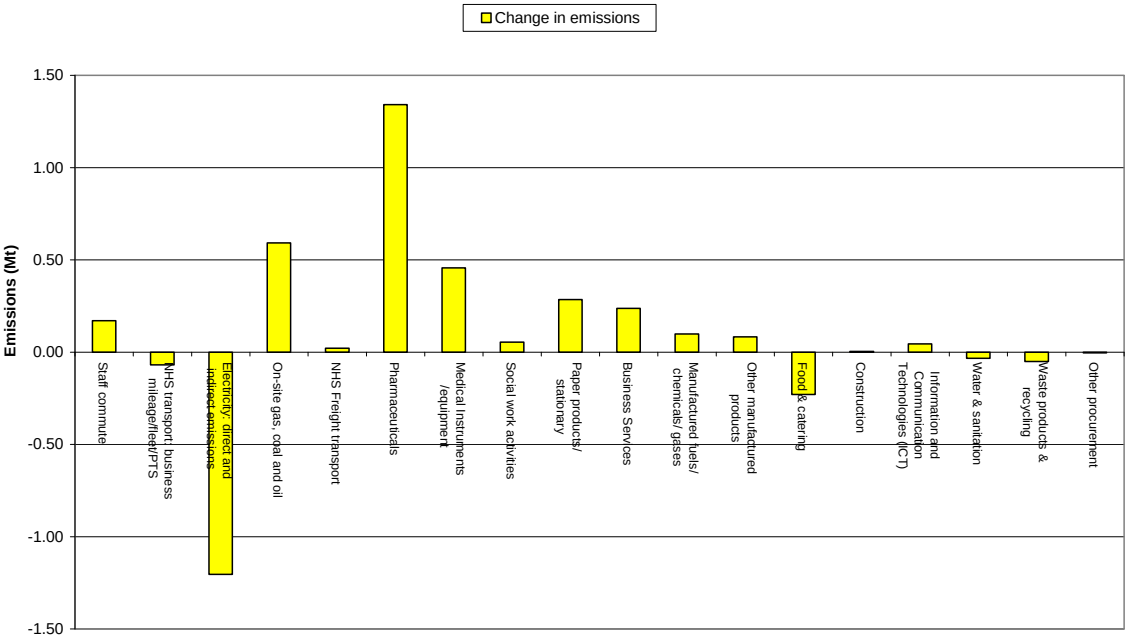


Figure 10: Change in emissions for each sector 1992 – 2004 (raw data table in Appendix B2.6)

Carbon intensity (comparison of consumption and carbon intensity)

Since 1992, the efficiency of the NHS has improved by just over 35%. For every million pounds of NHS spending in 1992, 910 tonnes of CO_2 were released. Today, for every million pound spent the NHS emit 570 tonnes of CO_2[21] (for a sector breakdown see Appendix B3). Whilst the carbon intensity of the NHS has reduced, this has not been enough to achieve a reduced carbon footprint. Any savings made by improving the efficiency of production has been offset by rising expenditure (see figure 11 below).

Figures 12 and 13 give the same breakdown for NHS energy use and procurement[22]. Both have improved significantly in terms of less CO_2 being emitted per pound NHS England spending. Improvements in the efficiency of providing pharmaceuticals have been offset by rising demand for pharmaceuticals, whereas overall emissions from energy use have been reduced since 1992. Yet this is due to considerable improvements in energy efficiency, but not reduced demand in terms of kWh use.

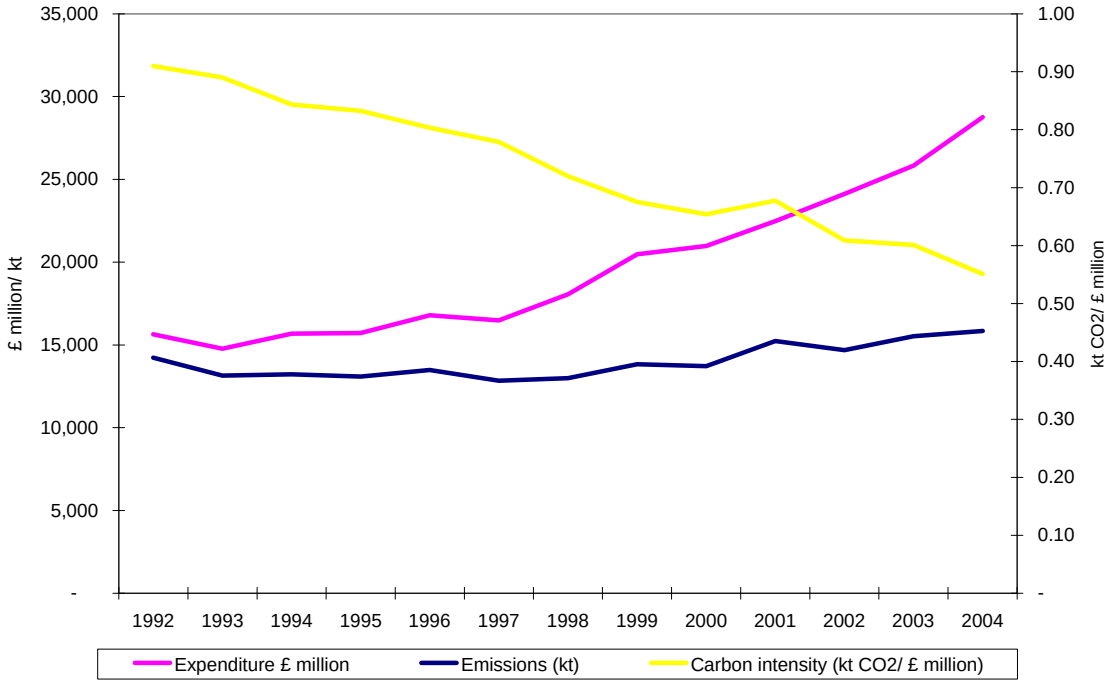


Figure 11: Changes in expenditure, emissions and carbon intensity of production of the NHS England (raw data table in Appendix B2.7)

[21] This takes into account inflation over this time period using the Consumer Price Index (CPI) to adjust NHS England spending.

[22] Data for staff, patient and visitor travel was collected using a different method outlined in appendix 1, which means this analysis is not possible for the travel sector

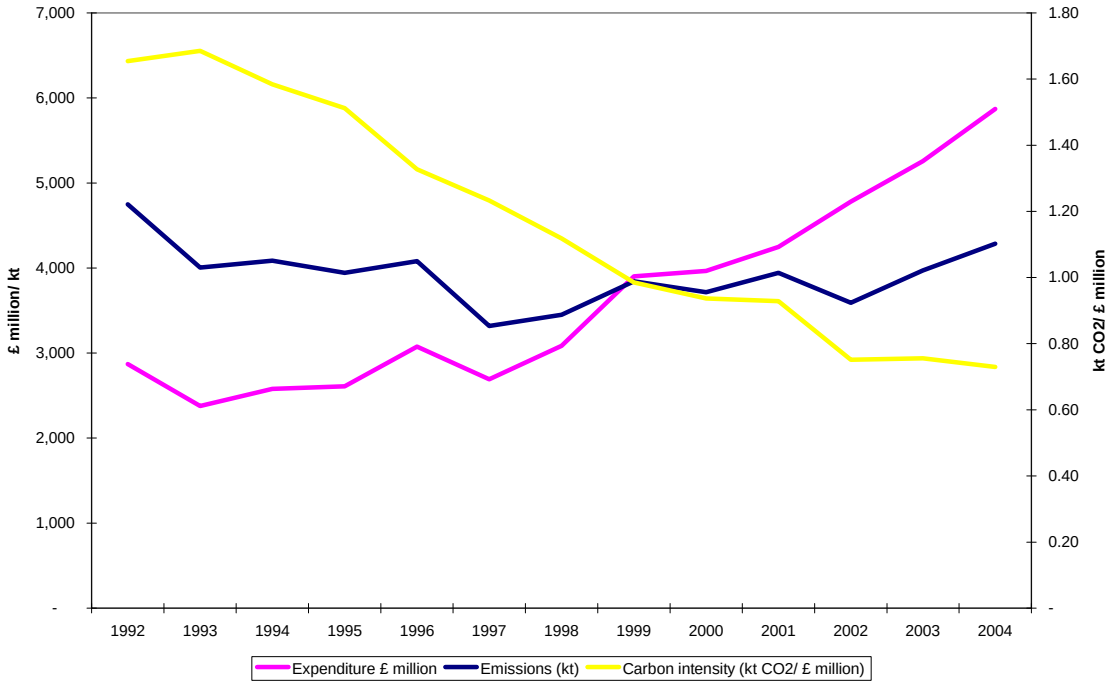


Figure 12: Changes in expenditure, emissions and carbon intensity of production of NHS Building Energy (raw data table in Appendix B2.8)

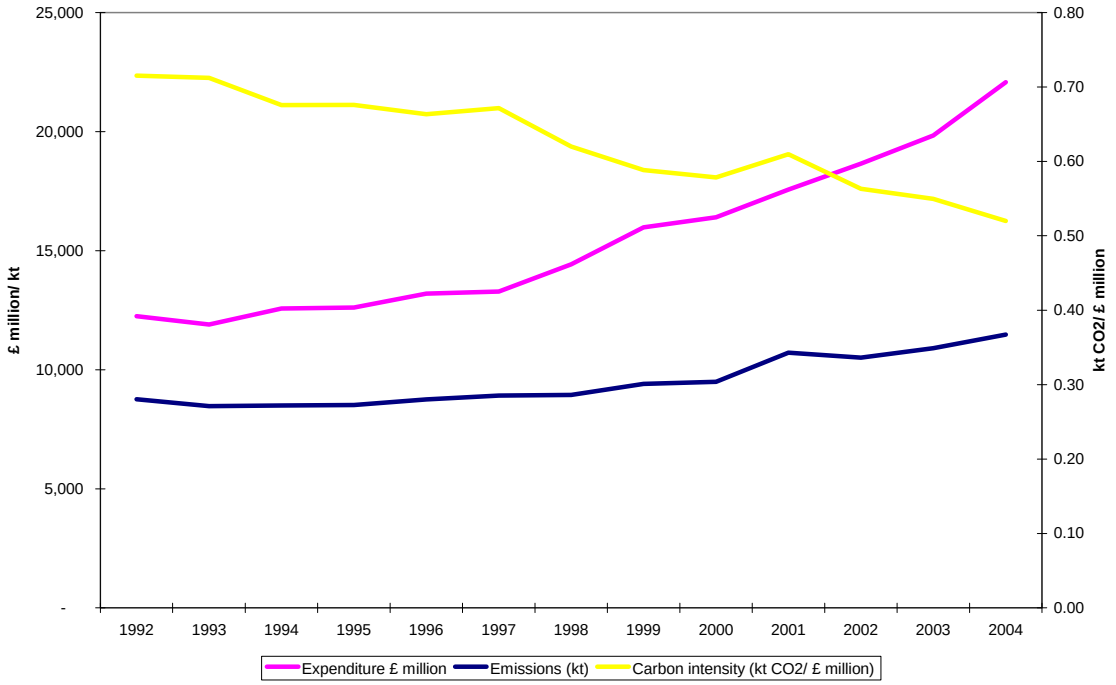


Figure 13: Changes in expenditure, emissions and carbon intensity of production of NHS Procurement (raw data table in Appendix B2.9)

Case Study of Key NHS Suppliers – Pharmaceuticals and Medical Equipment

Structural Path Analysis

Within the first study, SEI identified that procurement was the largest of the three primary sectors, contributing 60% to overall emissions. In turn the two largest sub-sectors (together comprising over 50% of procurement emissions) are pharmaceuticals and medical equipment. The further breakdown of these two sub-sector emissions was not part of the original footprinting project, but this can now be achieved in this work package using a Structural Path Analysis (SPA) model, based on the SRIO analysis. The SPA results will provide information as to the origins of these emissions, which will be useful not only for the strategy but also to provide a basis for engagement with the relevant supply chains.

A Structural Path Analysis "unravels" a sector's impacts into single contributing supply paths. It gives extensive detail of the impact of a sector's or company's activities. If we imagine the pharmaceutical and medical instrument industries are two *companies* that supply the NHS England, we can look at the CO_2 impacts of these companies. From our analysis we know that the total emissions embedded in pharmaceutical products bought by the NHS are just over 4 Mt CO_2 and 1.7 Mt CO_2 are embedded in medical instruments purchased.

Following the GHG Protocol Corporate Standard, 63% of the 4 Mt tonnes CO_2 embedded in pharmaceuticals is emitted directly at pharmaceutical factories. This is mainly from gas use, for example to heat the premises. 22% is embedded in electricity used by the pharmaceutical industry and the other 15 % is emitted along the pharmaceutical supply chain (see figure 12). These are emissions embedded in goods and services bought by the pharmaceutical industry.

Whilst most emissions from the medical instrument industry are emitted from gas use on-site and from electricity use, almost 30% of the industry's emissions are embedded in the products they purchase. Box 1 uses the pharmaceutical industry as an example to illustrate where these emissions occur along the supply chain.

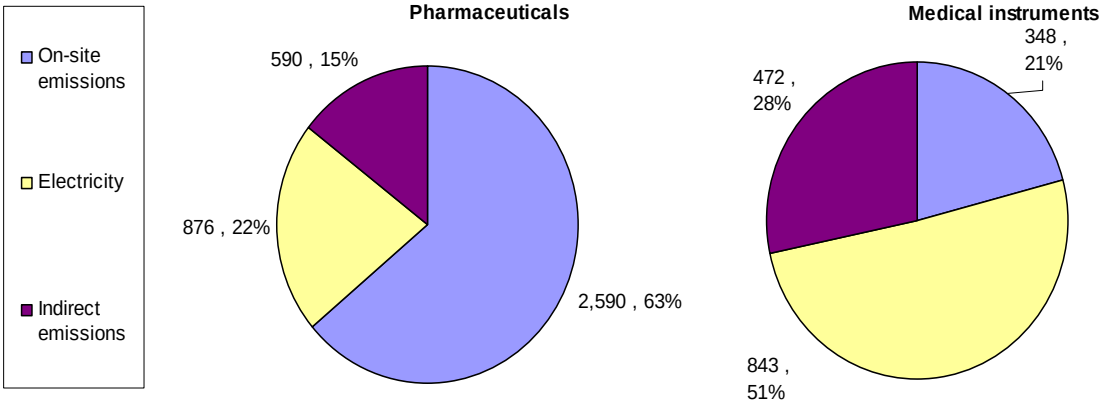


Figure 12: Carbon footprint of the pharmaceutical and medical instrument industries (kt) (raw data table in Appendix B2.10)

Box 1: Unravelling the supply chain: an example of the pharmaceutical industry

The supply chain of the pharmaceutical industry providing goods bought by the NHS is illustrated in figure 13. Layer 1 represents NHS procurement of pharmaceuticals. Layer 2 is on-site production of pharmaceuticals at the pharmaceutical factories. The pharmaceutical industry will buy other products, for example paper products, chemicals and energy to produce the pharmaceuticals. Layer 3 is direct suppliers of these products to the pharmaceutical industry. In turn, these industries need goods, energy and services. Layer 4 is suppliers to suppliers of the pharmaceutical industry. There are an infinite number of suppliers along the supply chain; however, the model used assumes that by the 20th production layer, the order of emissions from production will have diminished to almost zero and uses this as a cut off point.

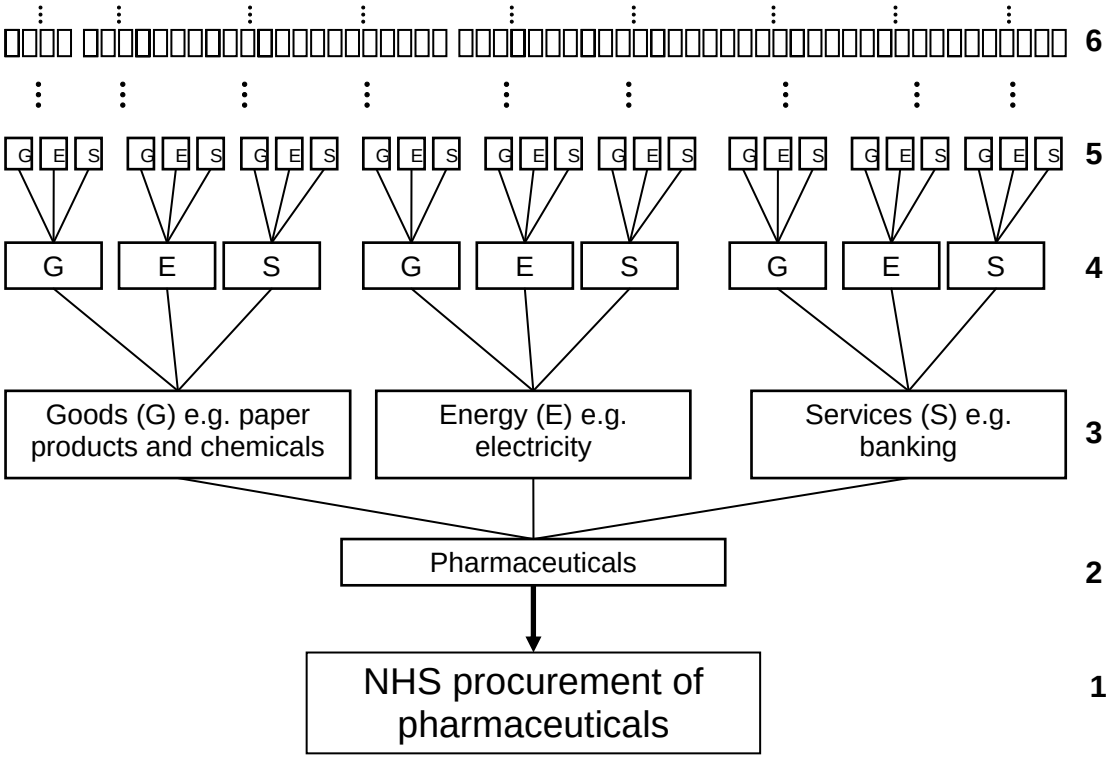


Figure 13: Supply chain of the pharmaceutical industry providing goods bought by the NHS

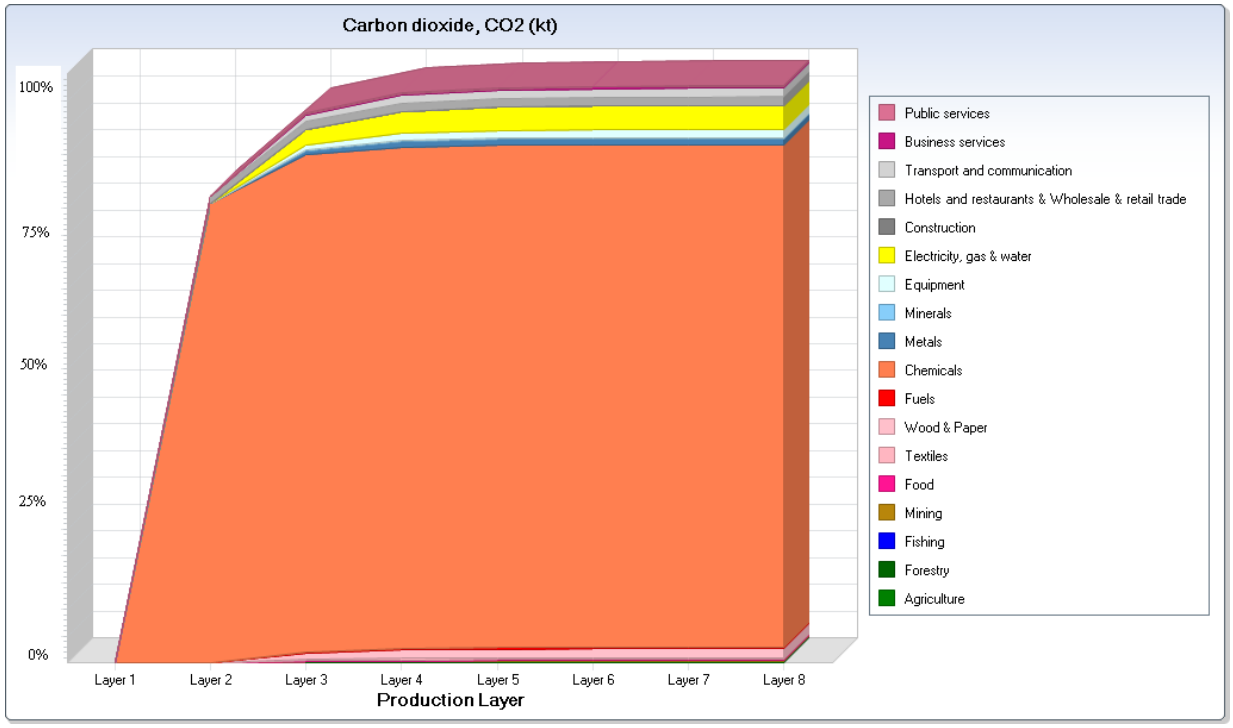
Using the pharmaceutical industry example, Appendix B4 offers explains how to calculate indirect emissions along the supply chain.

Indirect emissions of pharmaceuticals and medical equipment

From the SPA analysis, the indirect emissions of the pharmaceuticals and medical equipment sectors can be examined. This is useful as it means that the sources of the emissions can be estimated in terms of supply chain layers.

Pharmaceuticals

The analysis results are shown in Table 2 and Figure 14 below. These show that 80% emissions are directly from the pharmaceutical industry (layer 2). [Note that the emissions are grouped in Figure 14 into sectors, and so pharmaceutical company emissions – layer 2 – are contained within 'chemicals' and comprise nearly all the emissions in that sector]. Direct suppliers to the pharmaceutical industry (layer 3) add about 12% to the carbon footprint of pharmaceuticals. These direct suppliers are from a range of industries, most notably other chemical industries, energy suppliers and the paper industry. The remaining 8% emissions are added through suppliers to suppliers of the pharmaceutical industry and even further up the supply chain (layer 4 onwards).



Layer 1: NHS procurement of pharmaceuticals

Layer 2: Pharmaceutical industry i.e. pharmaceutical factories

Layer 3: Suppliers to pharmaceutical industry

Layer 4: Suppliers to suppliers of the pharmaceutical industry

Layer 5+: suppliers to suppliers…

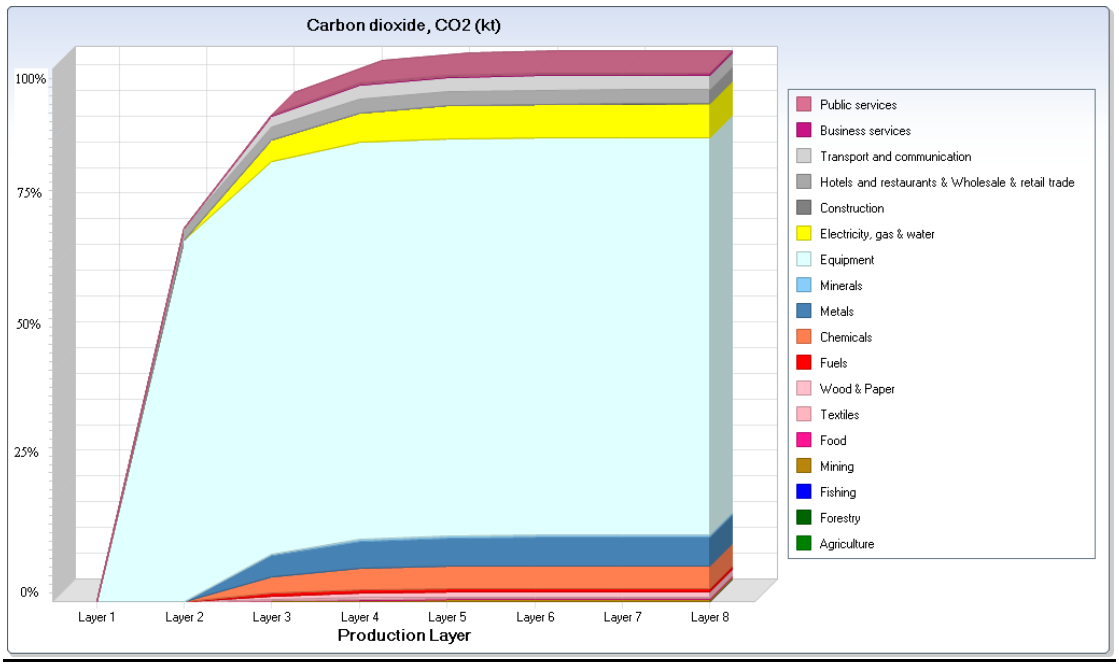
Figure 14: Carbon footprint of NHS procurement of pharmaceutical products by production layer

Rank	Path Description	Path Value	Path Order	Percentage in total impact
1	Pharma industry > Pharmaceuticals	1,718 kt	2	79.6 %
2	Pharma industry > Pharma industry > Pharmaceuticals	79.6 kt	3	3.69 %
3	Electricity production and distribution > Pharma industry > Pharmaceuticals	46.8 kt	3	2.17 %
4	Inorganic chemicals > Pharma industry > Pharmaceuticals	27.6 kt	3	1.28 %
5	Pulp and paper > Pharma industry > Pharmaceuticals	21.5 kt	3	1.00 %
6	Wholesale distribution > Pharmaceuticals	13.9 kt	2	0.64 %
7	Organic chemicals > Pharma industry > Pharmaceuticals	12.9 kt	3	0.60 %
8	Plastic products > Pharma industry > Pharmaceuticals	10.7 kt	3	0.49 %
9	Retail distribution > Pharmaceuticals	10.1 kt	2	0.47 %
10	Non-ferrous metals > Pharma industry > Pharmaceuticals	9.73 kt	3	0.45 %
11	Electricity production and distribution > Electricity production and distribution > Pharma industry > Pharmaceuticals	9.07 kt	4	0.42 %
12	Mechanical machinery and equipment > Pharma industry > Pharmaceuticals	8.32 kt	3	0.39 %
13	Road transport > Wholesale distribution > Pharmaceuticals	7.75 kt	3	0.36 %
14	Electricity production and distribution > Retail distribution > Pharmaceuticals	4.91 kt	3	0.23 %
15	Road transport > Pharma industry > Pharmaceuticals	4.32 kt	3	0.20 %
16	Motor vehicle distribution and repair, automotive fuel retail > Pharmaceuticals	4.02 kt	2	0.19 %
17	Furniture and miscellaneous manufacturing > Pharma industry > Pharmaceuticals	3.98 kt	3	0.18 %
18	Textiles > Pharma industry > Pharmaceuticals	3.79 kt	3	0.18 %
19	Pharma industry > Pharma industry > Pharma industry > Pharmaceuticals	3.69 kt	4	0.17 %
20	Electricity production and distribution > Wholesale distribution > Pharmaceuticals	3.56 kt	3	0.16 %

Table 2: SPA analysis of supply chain emissions of pharmaceutical sector

Medical instruments

A similar pattern is apparent from a breakdown of the medical instrument supply chain, shown in Table 3 and Figure 15. These show that 70% emissions are directly are directly from factories producing the instruments (layer 2). [Note that the emissions are grouped in Figure 14 into sectors, and so medical equipment company emissions – layer 2 – are contained within ‘equipment and comprise nearly all the emissions in that sector]. Direct suppliers to the medical equipment industry (layer 3) add about 16% to the carbon footprint of medical equipment. Emissions are embedded in plastics, metals, electricity and electrical machinery purchased by the medical instrument industry. The remaining 14% emissions are added through suppliers to suppliers of the industry and even further up the supply chain (layer 4 onwards).



Layer 1: NHS procurement of medical instruments

Layer 2: Medical Instrument industry i.e. medical instrument factories

Layer 3: Suppliers to medical instrument industry

Layer 4: Suppliers to suppliers of the medical instrument industry

Layer 5+: suppliers to suppliers…

Figure 15: Carbon footprint of NHS procurement of medical instruments by production layer

Rank	Path Description	Path Value	Path Order	Percentage in total impact
1	Medical instruments industry > Medical Instruments	422 kt	2	68.4 %
2	Electricity production and distribution > Medical instruments industry > Medical Instruments	19.8 kt	3	3.22 %
3	Plastic products > Medical instruments industry > Medical Instruments	11.9 kt	3	1.93 %
4	Iron and steel > Medical instruments industry > Medical Instruments	11.3 kt	3	1.83 %
5	Electrical machinery and equipment > Medical instruments industry > Medical Instruments	10.9 kt	3	1.76 %
6	Radio, television and communications > Medical instruments industry > Medical Instruments	9.64 kt	3	1.56 %
7	Non-ferrous metals > Medical instruments industry > Medical Instruments	8.72 kt	3	1.41 %
8	Medical instruments industry > Medical instruments industry > Medical Instruments	6.96 kt	3	1.13 %
9	Wholesale distribution > Medical Instruments	6.80 kt	2	1.10 %
10	Retail distribution > Medical Instruments	4.91 kt	2	0.80 %
11	Metal products > Medical instruments industry > Medical Instruments	4.24 kt	3	0.69 %
12	Electricity production and distribution > Electricity production and distribution > Medical instruments industry > Medical Instruments	3.84 kt	4	0.62 %
13	Road transport > Wholesale distribution > Medical Instruments	3.78 kt	3	0.61 %
14	Mechanical machinery and equipment > Medical instruments industry > Medical Instruments	2.64 kt	3	0.43 %
15	Pulp and paper > Medical instruments industry > Medical Instruments	2.48 kt	3	0.40 %
16	Electricity production and distribution > Retail distribution > Medical Instruments	2.40 kt	3	0.39 %
17	Road transport > Medical instruments industry > Medical	2.24 kt	3	0.36 %

	Instruments			
18	Furniture and miscellaneous manufacturing > Medical instruments industry > Medical Instruments	2.18 kt	3	0.35 %
19	Iron and steel > Metal products > Medical instruments industry > Medical Instruments	2.03 kt	4	0.33 %
20	Motor vehicle distribution and repair, automotive fuel retail > Medical Instruments	1.96 kt	2	0.32 %

Table 3: SPA analysis of supply chain emissions of medical equipment sector

Where do pharmaceuticals and medical instruments come from?

Pharmaceuticals

The preliminary analysis from the MRIO model suggests, whilst uncertainty exists[23], about one fifth of the embedded emissions in pharmaceuticals bought by the NHS in 2004 comes from domestic production, the rest - about 80% - comes from abroad, half of which are from non-OECD countries (figure 16).

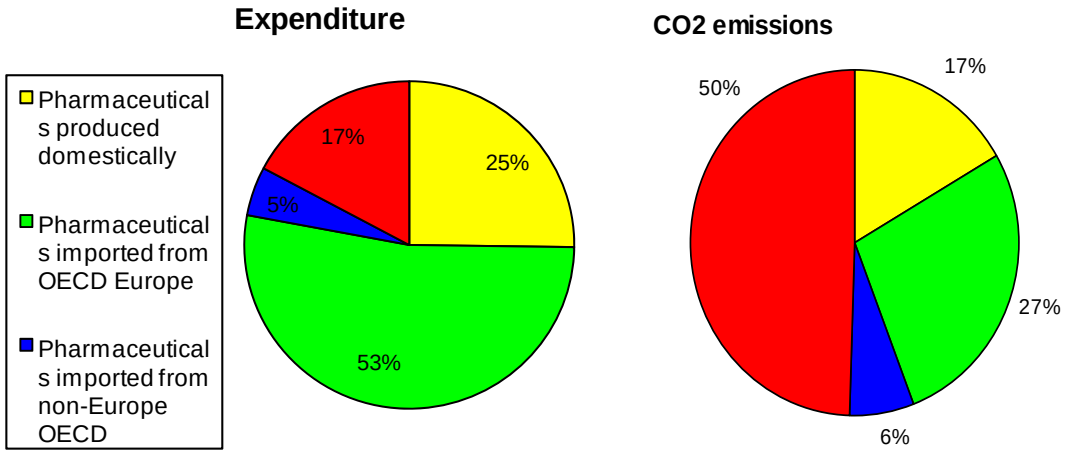


Figure 16: NHS spending on pharmaceutical products by origin and NHS embedded emissions from pharmaceutical products by origin[24] (raw data table in Appendix B2.11)

[23] Uncertainty report for the model: Wiedmann, T., Lenzen, M. and Wood, R. (2008) Uncertainty Analysis of the UK-MRIO Model – Results from a Monte-Carlo Analysis of the UK Multi- Region Input-Output Model (Embedded Emissions Indicator); Report to the UK Department for Environment, Food and Rural Affairs by Stockholm Environment Institute at the University of York and Centre for Integrated Sustainability Analysis at the University of Sydney. Defra, London, UK

[24] This represents the proportion of average expenditure on pharmaceutical/ medical instrument products in the UK. The NHS are responsible for the majority of the market (approximately two thirds), therefore this is taken as a fair representation of pharmaceutical/ medical instrument procurement of the NHS England.

The NHS procures 25% of its pharmaceutical products domestically. Half of NHS spending on pharmaceuticals is on pharmaceutical products imported from European OECD countries. However, when looking at the related emissions, the same pattern is not reflected.

Whilst half of the pharmaceutical products are sourced from European OECD countries, this represents only a quarter of overall embedded emissions. The majority of emissions from procurement of pharmaceuticals are embedded in products imported from non-OECD countries. 17% of emissions are embodied in pharmaceutical products produced within the UK.

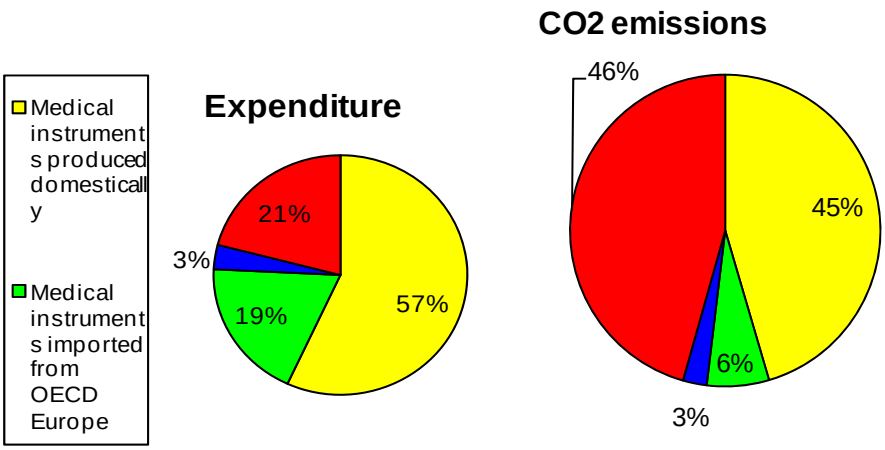
Efficiency of production is significantly better in the UK than in non-OECD countries, and this is reflected in the notably higher emissions from these countries (table 4). Whilst NHS expenditure on pharmaceutical products from non-OECD countries is almost a third less than the purchase of pharmaceuticals from the UK, emissions are almost three times higher.

Pharmaceuticals origin (2004)	**Expenditure (£M)**	**CO_2 emissions (Mt CO_2)**	**Carbon intensity (kg CO_2/£ spent)**
UK	1.81	0.69	0.38
OECD Europe	3.83	1.09	0.28
Non-Europe OECD	0.36	0.24	0.67
Non OECD	1.23	2.03	1.65
Total	**7.23**	**4.05**	**0.56**

Table 4: Expenditure, emissions and efficiency of production of pharmaceuticals by origin[25]

Medical instruments

About half of the embedded emissions in medical instruments bought by the NHS come from domestic production; the other half comes mostly from non-OECD countries (figure 17).



[25] Figures from out with the UK are based on a high level of aggregation, with pharmaceuticals being included in a more extensive chemicals sector. For an uncertainty analyses of the model refer to Weidmann et al. (2008)[23].

Figure 17: NHS spending on medical products by origin and NHS embedded emissions from medical products by origin[24] (raw data table in Appendix B2.12)

Similar to pharmaceuticals, it is significantly more efficient to buy medical products manufactured in European-OECD countries than those produced in non-OECD countries (table 5). Only 21% NHS spending on medical products is spent on imported products from outwith OECD-countries, yet they cause a disproportionate share of emissions due to more carbon intensive production methods.

Medical Equipment origin (2004)	Expenditure (£M)	CO_2 emissions (Mt CO_2)	Carbon intensity (kg CO_2/£ spent)
UK	2.04	0.75	0.37
OECD Europe	0.68	0.10	0.15
Non-Europe OECD	0.11	0.03	0.27
Non OECD	0.75	0.78	1.04
Total	3.58	1.66	0.46

Table 5: Expenditure, emissions and efficiency of production of pharmaceuticals by origin[25]

Have these sectors reduced their carbon intensity?

Figure 18 looks at the changes in NHS expenditure on pharmaceuticals, the related CO_2 emissions and the intensity of production of the industry over time. NHS expenditure on pharmaceuticals has increased significantly, with a more pronounced rise since 1997. The efficiency of the industry has improved, which has offset some of the emissions from the increasing demand by the NHS, but absolute emissions continue to rise. The same is true for medical instruments (figure 19).

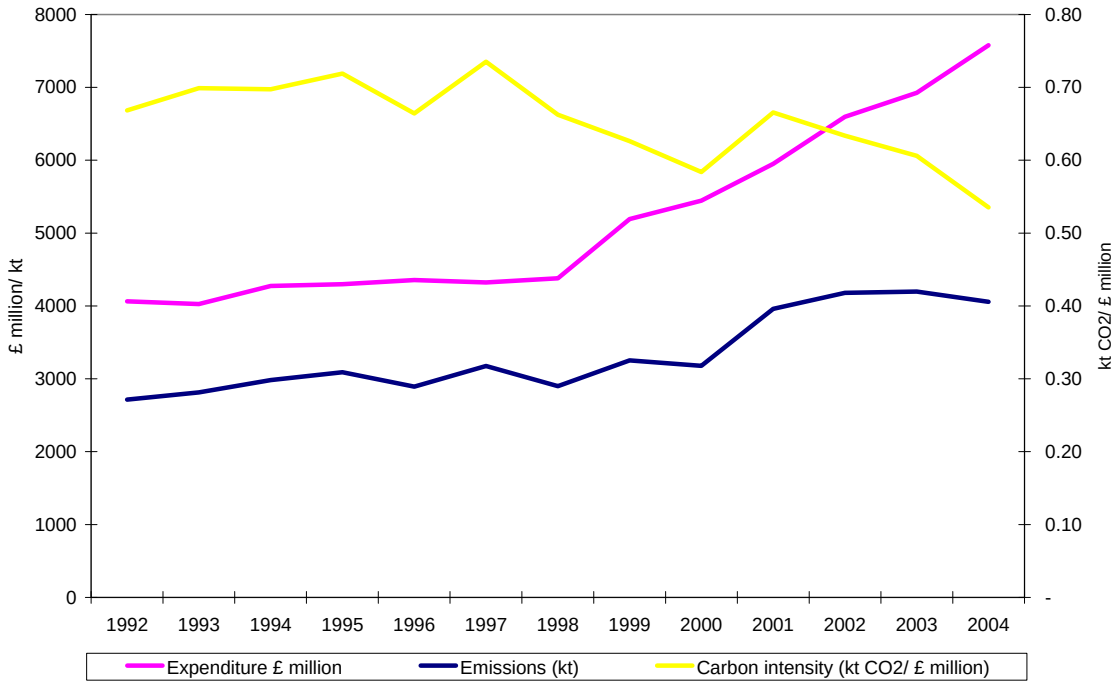


Figure18: Changes in expenditure, emissions and carbon intensity of production of the pharmaceutical industry (raw data table in Appendix B2.13)

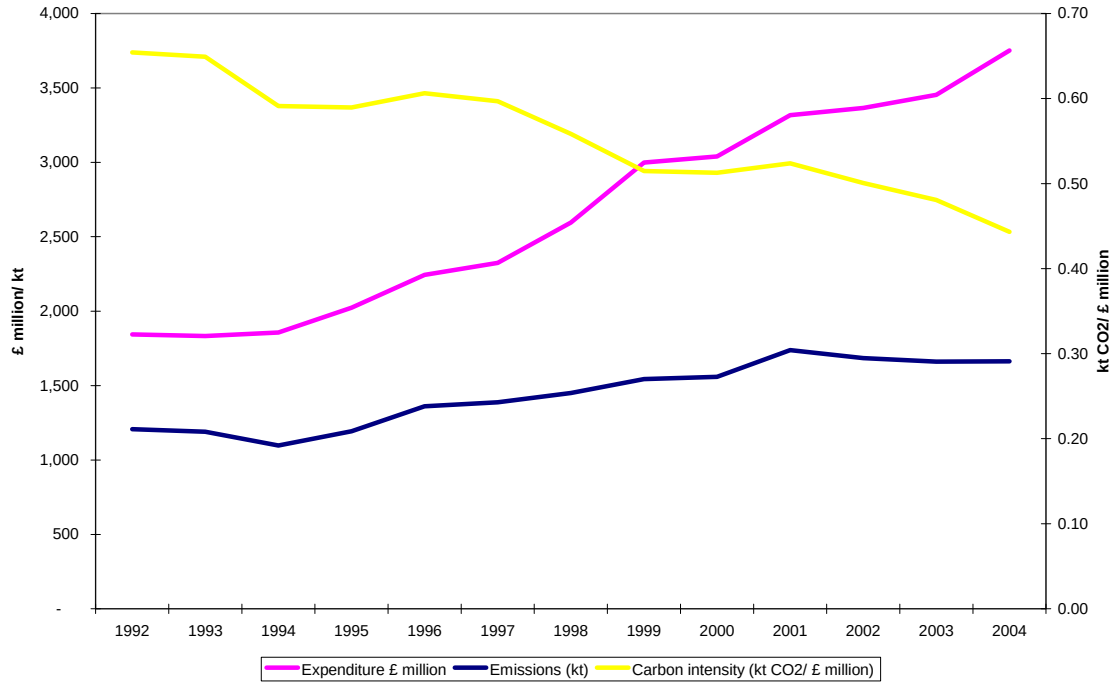


Figure19: Changes in expenditure, emissions and carbon intensity of production of the medical instrument industry (raw data table in Appendix B2.14).

Conclusions and Recommendations

As a result of this analysis there are several key conclusions and recommendations:

- 60% of NHS England emissions are indirect, highlighting the importance of taking scope three of the GHG Protocol into account.
- Scope three emissions continue to rise, which underlies the importance of including this in NHS carbon accounting.
- Whilst emissions from energy have been reduced due to improvements in energy efficiency, the demand for energy has not reduced. Further efforts are needed to reduce the use of energy and its impact; especially as the NHS have most control over these.
- Whilst the NHS has become more efficient, overall emissions have not been reduced. Any savings made by improving the efficiency of production have been offset by rising expenditure.
- The NHS needs a clear procurement procedure which builds on the evidence provided in this report. The pharmaceutical industry is both a significant and growing supplier, and must be a focus of the NHS.

The carbon footprint of NHS England: an input-output analysis

18.03.2008

Scott, K., Minx, J. and Barrett, J.

The methodological approach

This report measures the carbon footprint of the NHS in England from a *consumption perspective*[26], which seeks to include all carbon emissions associated with the consumption of a particular good or service in the UK, wherever they occur geographically. Emissions produced throughout the industrial supply chain to provide goods and services purchased by the government in order to provide the NHS in England, whether produced in the UK or abroad, are taken into account.

NHS carbon emissions are calculated using a top-down approach complemented with available bottom-up data.

Based on input-output methodology, a top-down approach, we are able to calculate the carbon emissions (carbon dioxide and greenhouse gases) associated with the procurement of goods by the NHS, i.e. embodied emissions of the goods and services consumed by the government in order to provide health services. These include direct and indirect emissions.

Direct emissions occur on-site and are internal to the provision of health services. Indirect emissions occur off-site through the pollution and resource consumption caused in the production of goods and services consumed by the NHS. The sum of these direct and indirect emissions is termed the total emissions.

The majority of carbon impacts are not associated with the direct emissions from heating buildings and driving cars, but with the indirect embodied emissions from products purchased/ consumed. Box 1 illustrates this through the example of purchasing a car. The same principle can be applied to the purchase of medical equipment, pharmaceuticals and so on.

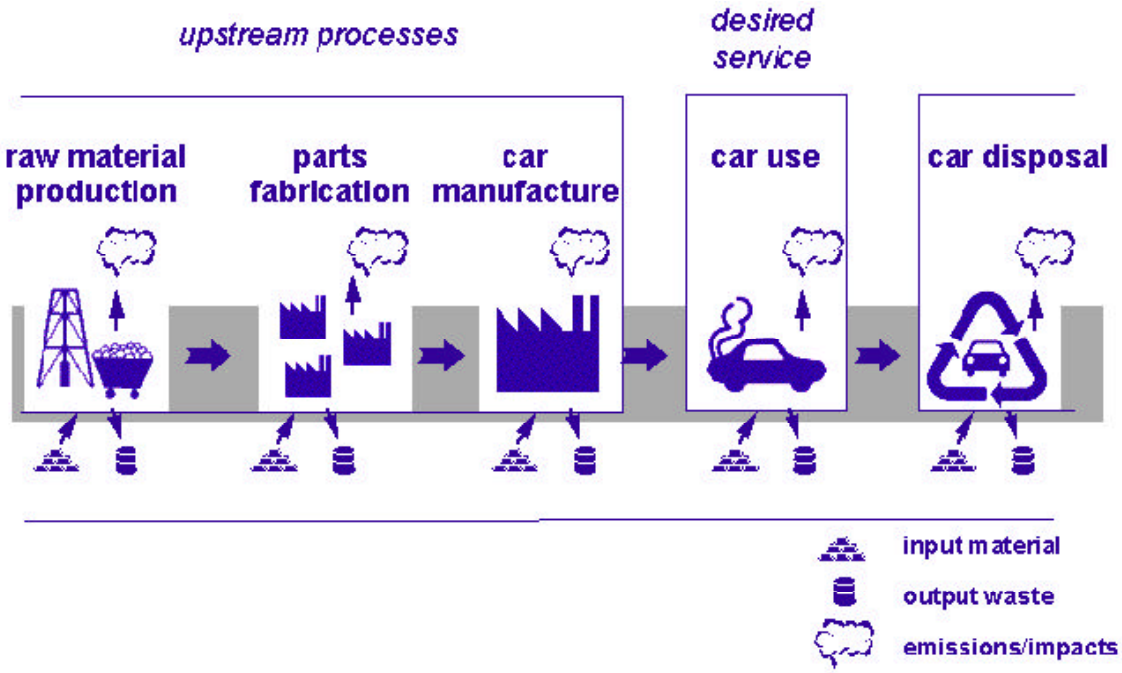
In the past, studies have focused on measuring direct emissions; however, it is vital to measure indirect emissions in order for the NHS to reduce its full carbon impact. This is possible using an input-output approach.

[26] SEI, WWF and CURE, 2006, Counting Consumption. CO_2 Emissions, Material Flows and Ecological Footprint of the UK by Region and Devolved Country, WWF-UK, Surrey.

Box 1: Emissions associated with the purchase of a car

The carbon impacts of a car are not only related to the emissions of driving it, but also to emissions associated with raw material extraction, manufacturing, distribution and disposal of the car.

In the production process there is a hierarchy of production layers, and each one of them needs inputs like materials and energy. The (raw) materials and parts to manufacture the car will be purchased from a range of specialised industries upstream. It is likely that they themselves obtained materials from other industries and so on. The parts of the car are transported downstream to factories in order to put the car together and deliver it to retailers. All these steps use up resources and emit pollution in the process, pollution and resource use that should be accounted for when calculating the emissions associated with purchasing a car.



Once the car is sold to consumers, additional resources are required and pollution is generated when people drive it. Whilst many consider only the emissions released driving a car, this example demonstrates that there are a lot of indirect environmental impacts hidden in the complex combination of production layers, sectors and even countries involved in its fabrication.

In order to provide a carbon footprint of the NHS there are three sources of carbon emissions that need to be measured: direct carbon emissions from building energy use, travel carbon emissions, and embodied carbon emissions (Figure 1).

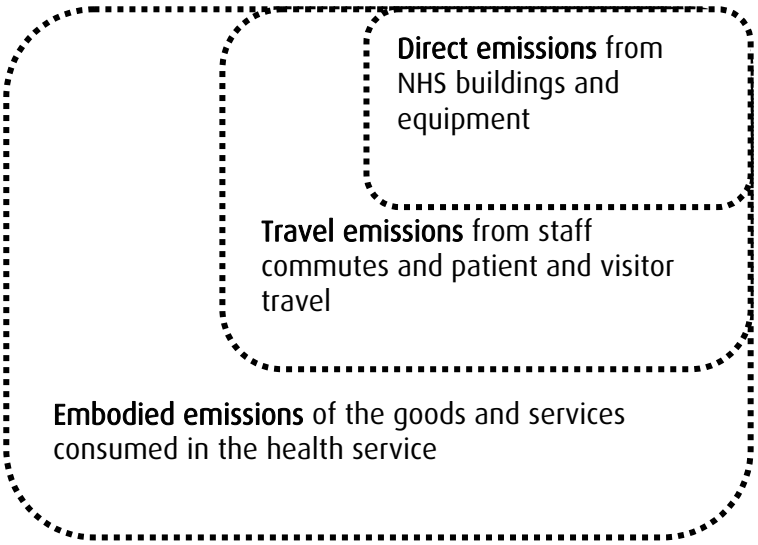


Figure 1: Basic components of carbon footprint of NHS England

Input-output analysis calculates the embodied emissions and building energy emissions[27]. Direct emissions from local electricity production are calculated using bottom-up data specific to the NHS[28]. National travel survey data is used to estimate staff, patient and visitor travel, not gained from the input-output analysis. Input-output analysis provides relatively highly aggregated results and provides UK average emissions for industrial sectors.

Table 1 presents the data and data sources required to calculate these emissions.

Emission type	Emission source	Data source
Direct CO_2 emissions	Energy use in NHS buildings	2004 UK input-output table, CO_2 and GHG emissions from UK Environmental Accounts 2004 and ERIC data 2004-5
Travel CO_2 emissions	Direct and indirect emissions from patient, visitor and staff travel to and from health services	National travel survey 2004 and estimates
Embodied CO_2 emissions	Emissions from the procurement of goods and services consumed in the NHS arising in the industrial supply chain	2004 UK input-output table and CO_2 and GHG emissions from UK Environmental Accounts 2004

Table 1: NHS carbon emissions and data sources

[27] This includes electricity supplied from a generation plant, coal, oil, gas, hot water and steam

[28] Estates return information collection 2004/5 provided by the NHS

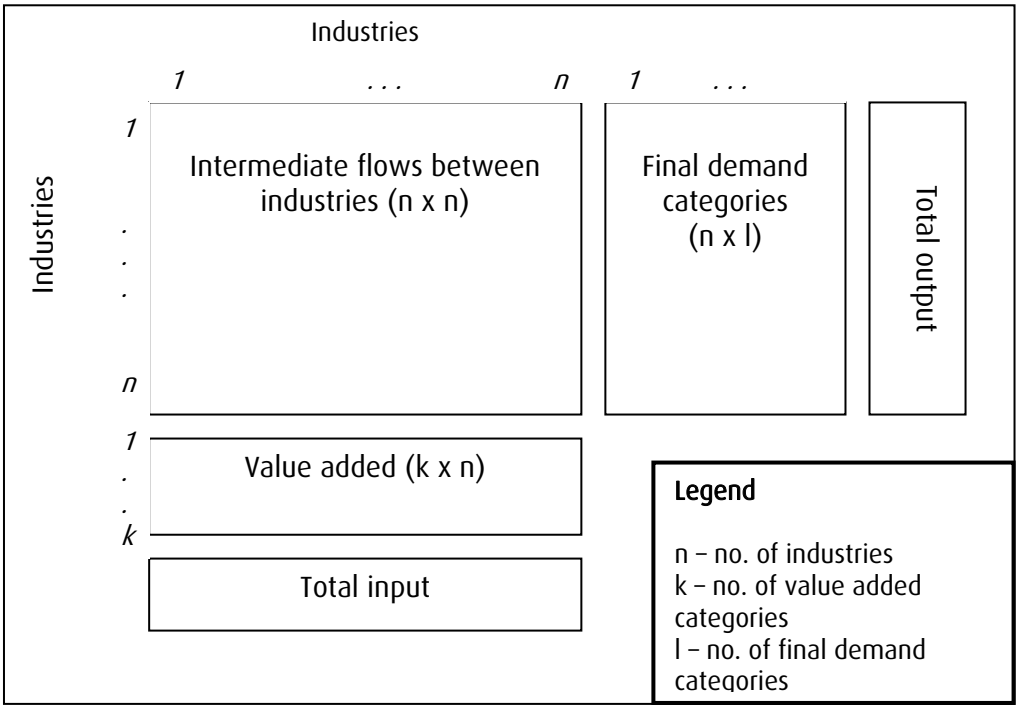
Calculation of embodied emissions: a top-down approach

For calculating the carbon footprint of the NHS the Resources and Analysis Programme (REAP) developed by the Stockholm Environment Institute has been adapted (Wiedmann and Barrett, 2005)[29]. The relevant part of the REAP tool for estimating the carbon emissions of the NHS is based on an input-output framework, as proposed by Leontief in the 1930s (for a guide to input-output analysis see Miller and Blair, 1985[30]; Leontief, 1970[31]; Leontief, 1986[32]).

Input-output tables describe the flow of goods and services between all the individual sectors of an economy over a stated period of time, commonly a year. The sectors of an economy range from agricultural and manufacturing industries (for example meat production and chemical production) to transport, recreational, health and financial services.

The table describes the monetary transactions occurring between the industrial sectors, value added and final demand categories. Sectors exchange goods and services e.g. steel bought by the vehicle industry or meat bought by the catering industry. There are sales to external purchasers, such as households, the government and foreign trade. Also in producing goods and services sectors pay for other items such as labour, capital and imported goods, known as value added.

Figure 2 shows how an input-output table is presented, with the main component being a transactions matrix of the industrial sectors. Each row of the table indicates the distribution (sale) of an industries output to other domestic industries and to final demand. Each column shows the amounts of inputs purchased from other industries and value added categories.



[29] Wiedmann,T. and Barrett, J. (2005). The use of input-output analysis in REAP to allocate footprints and material flows to final consumption activities, REAP Report No. 2, Stockholm Environment Institute, York, available at www.sei.se/reap.

[30] Miller, R.E. and Blair, P.D. (1985). Input-output analysis: foundations and extensions, New Jersey, Eaglewood cliffs.

[31] Leontief, W (1970), taken from Kurz, H.D., Dietzenbacher, E. And Lager, C (1998), Input-output analysis Volume II, Cheltenham, Edward Elgar Publishing Lt.

[32] Leontief, W (1986), Input-output economics, New York, Oxford University Press.

Figure 2: General structure of an input-output table

Initially developed to analyse the interdependencies of industries in an economy, input-output analysis has since been extended to account for environmental impacts, such as pollution and resource consumption. If you have energy use or pollution emitted by industrial sector (in physical units), it is possible to calculate the direct and indirect environmental impacts of the consumption of goods and services by final demand.

Based on the assumption that each unit of a sector's product or service delivered to other production sectors or final consumers produces the same amount of pollution (for example carbon dioxide) per unit of sectoral output, sectoral carbon dioxide intensities (expressed in tons of carbon dioxide per unit of sectoral output) can be calculated and used for the estimation of all carbon emissions triggered throughout the supply chain by final demand as recorded in the input-output tables.

For the analysis of the NHS, a 2004 UK input-output table comprising of 178 industrial sectors and five final demand categories is used, provided by SEI[33,34], along with corresponding carbon dioxide and greenhouse gas emissions provided by National Statistics Environmental Accounts.

The sector of focus in this study is termed 'human health and veterinary activities' (sector 168 in the input-output table[35]). There is not a sector assigned to the NHS alone, and aggregation of sectors is a limitation of such an approach.

The input-output table indicates the purchases of the health and veterinary activities sector from other sectors, and the sectoral output of the health sector to final demand, in which government is of relevance for this study. Government spending on the health sector is taken as a representation of NHS activities at this stage. Whilst this spending could include spending by the department of health, for example, it is likely that by far the majority will be NHS expenditure.

As input-output analysis is a top-down approach and therefore calculates UK industry averages, a comparison of the energy use emissions generated by the input-output analysis and bottom-up data specific to NHS operations from ERIC data (provided by the NHS) has been carried out. The results are found to be similar, with a difference of approximately 0.1 Mt CO_2. There is scope to reconcile this data.

Figure 3 represents the data used for the carbon analysis of the NHS (an extended environmental input-output table adapted to the requirements of this project). NHS related expenditures are found in two parts of input-output tables:

- Purchases by the health sector of goods and services from other industrial sectors (the vertical red dotted line in figure 3)
- Government expenditure on the health sector in the final demand section (where the blue dashed line meets the horizontal red dotted line in figure 3). It has been assumed that the proportion of spending in England compared with the UK is 50/60, according to the population fraction.

[33] Wiedmann, T., Wood, R., Lenzen, M., Minx, J., Guan, D. and Barrett, J. (2007) Development of an Embedded Carbon Emissions Indicator – Producing a Time Series of Input-Output Tables and Embedded Carbon Dioxide Emissions for the UK by Using a MRIO Data Optimisation System, Report to the UK Department for Environment, Food and Rural Affairs by Stockholm Environment Institute at the University of York and Centre for Integrated Sustainability Analysis at the University of Sydney. Defra, London, UK (not yet published). Available only for 1995 at the 76 sector level from ONS.

[34] Only available in supply-and-use table format for 2004 at 123 sector level from the Office for National Statistics.

[35] This is sector 117 in the supply-and-use tables of the Office for National Statistics

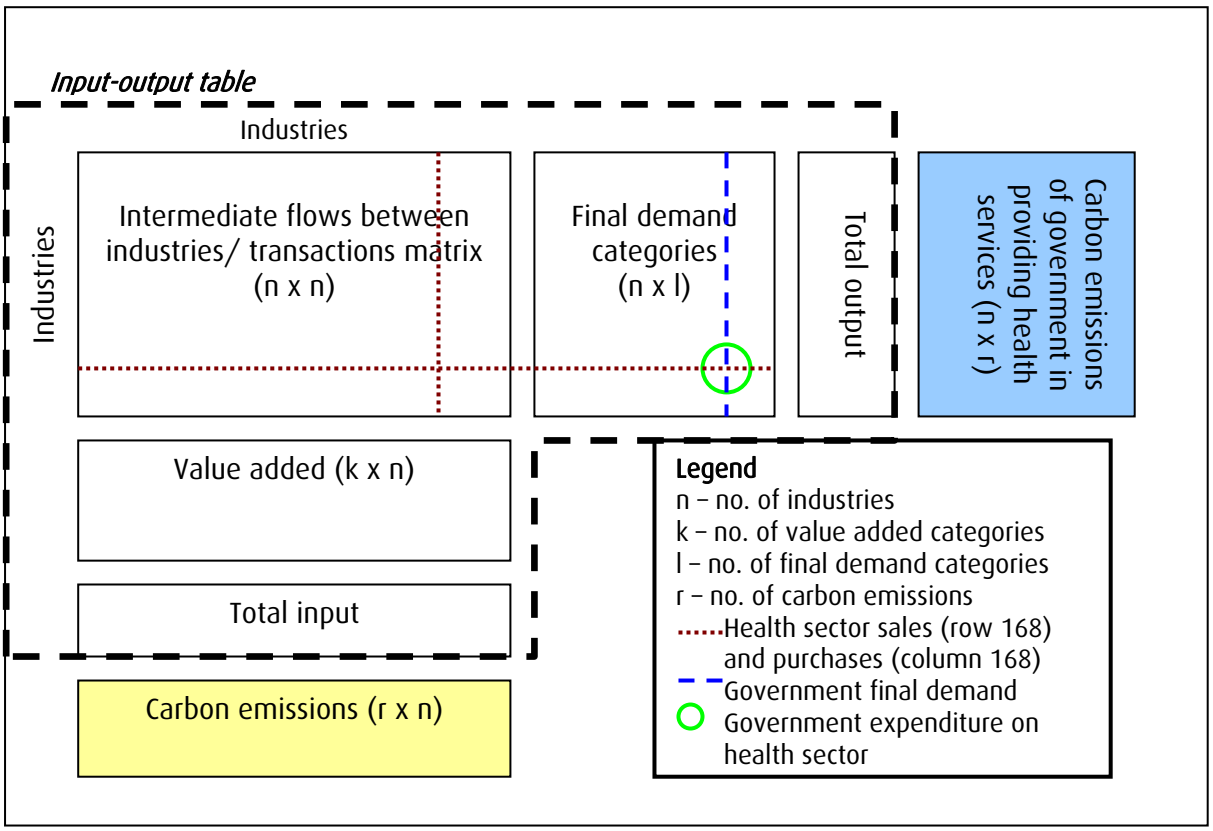


Figure 3: General structure of the environmental input-output table of the NHS

The emissions calculated represent the total English emissions from government spending on the health and veterinary sector (the blue box in figure 3). See Appendix B1.1 for full results. The emissions from 178 sectors can be aggregated into 3 main categories: travel, building energy and procurement, as shown in the table below:

Main sector	Sub sector	178 industrial sector numbers
Procurement	Pharmaceuticals	68
	Medical Instruments/equipment	103
	Business services	130, 144, 146-151, 157-163, 177
	Paper products	50-54
	NHS Freight transport	133, 137, 138, 140, 142, 143
	Other manufactured products	42, 44, 46, 48, 71-76, 87-88, 108, 111.
	Manufactured fuels/ chemicals/ gases	13, 56, 58-60, 69, 70
	Food and Catering	1-7, 19-35, 131
	Construction	77-79, 84, 122-124
	Information and Communication Technologies (ICT)	55, 96, 145, 154, 156
	Water & Sanitation	121, 170, 173
	Waste products and recycling	112, 113, 171-172
	Other procurement (includes industrial sectors which have zero emissions)	8-12, 14-18, 36-41, 43, 45, 47, 49, 61-67, 80-83, 85-86, 89-95, 97-102, 105, 107, 109-110, 127-129, 153, 155, 164-167, 169, 174-176, 178
Building energy	Heating/hot water and Electricity (later allocated to sub-sectors in proportions of ERIC data)	114-120, 168
Travel	NHS travel	57, 104, 106, 125-126, 132, 134-136, 139, 141, 152

Table 2: Allocation of 178 sectors into three primary sectors and sub-sectors
(see Appendix B1.1 for classification of sectors)

Travel emissions

Travel emissions from staff commutes, and patient and visitor travel to NHS facilities are not included in the input-output analysis, as these expenditures are attributed to household final demand, not government spending. However, they form an important part of the carbon footprint of the NHS. Travel emissions have been estimated using data from the 2004 National Travel Survey.

The estimated distance travelled to and from NHS services by staff, patients and visitors, is calculated in kilometres, and multiplied by conversion factors provided by SEI REAP. Conversion factors are the carbon emissions produced per unit of output, in this case kg CO_2 per km. Appendix B1.2 shows how these estimations are calculated.

These are added to the top-down data on NHS travel.

Direct emissions: a bottom-up approach

Specific information regarding the energy use of NHS buildings is available from ERIC data (Estates Return Information Collection). This gives the electricity, gas, oil, coal hot water and steam use in GJ (which are converted into kWh) of the NHS in England. These are multiplied by conversion factors provided by Defra[36]. The conversion factors are in kg CO_2 per kWh. For steam and hot water we have assumed gas as the energy source, which is the fuel with the lowest carbon impact. This may lead to a slight underestimation of emissions. Appendix B1.3 shows how these estimations are calculated.

The results are compared with the data generated by the input-output analysis and are found to be similar, with approximately a difference of 0.1 Mt CO_2. From the input-output analysis, one figure is given for emissions from on-site energy use by the NHS[37]. This is disaggregated between coal, oil and gas according to NHS energy mix, obtained from ERIC data (see Appendix B1.4).

On-site electricity generation at NHS facilities is added onto the energy use emissions, as this is not generated in the input-output analysis as there will have been no monetary transactions reflected in the input-output table.

Comparative CO_2 emissions

To facilitate direct comparisons between the CO_2 emissions for NHS England against other sectors, it is necessary to calculate equivalent consumption (rather than production) emissions. Total consumption emissions for the different regions of the UK are taken from REAP, as are total emissions from government spending only. These are shown in Appendix B1.5.

[36] DEFRA (2005). Guidelines for company reporting on Greenhouse gas emissions, available at http://www.defra.gov.uk/environment/business/envrp/pdf/envrpgas-annexes.pdf.

[37] This is the energy from coal, oil and gas, which are burned on-site, as opposed to electricity which is generated externally and distributed to buildings

Appendix B1.1: Total emissions of the NHS supply chain from 178 sectors

Sources: Input-output analysis of the NHS, using a 2004 UK input-output table comprising of 178 industrial sectors and five final demand categories is used, provided by SEI[38], along with corresponding carbon dioxide and greenhouse gas emissions provided by National Statistics Environmental Accounts.

NACE industry		2004 Government intermediate expenditure on health - England (£ million)	Carbon intensity by NACE industry (kg/ £ spent)	2004 NACE industry CO_2 emissions (kt)
1	Conventional Growing of cereals, vegetables, fruits and other crops	5.07	0.84	4.26
2*	Organic Growing of cereals, vegetables, fruits and other crops			
3	Growing of horticulture specialities and nursery products	0.77	0.97	0.74
4	Conventional Farming of livestock (except poultry)	7.67	0.84	6.41
5*	Organic Farming of livestock (except poultry)			
6	Conventional Farming of poultry	1.42	0.91	1.30
7*	Organic Farming of poultry			
8	Forestry, logging and related service activities (conventional)	0.00	0.00	0.00
9	Forestry and logging and related service activities ('sustainable' / FSC)	0.00	0.00	0.00
10	Fishing	0.00	0.00	0.00
11	Fish farming (non-organic)	0.00	0.00	0.00
12	Fish farming (organic/sustainable)	0.00	0.00	0.00
13	Mining of coal and lignite; extraction of peat	1.66	0.99	1.64
14	Extraction of crude petroleum and natural gas and Service activities incidental to oil and gas extraction, excluding surveying	0.00	0.00	0.00
15	Mining of uranium and thorium ores	0.00	0.00	0.00
16	Mining of iron ores	0.00	0.00	0.00
17	Mining of non-ferrous metal ores, except uranium and thorium ores	0.00	0.00	0.00
18	Mining and quarrying of stone, gravel, clays, salt, etc.	0.00	0.00	0.00
19	Conventional meat and meat products (excl. poultry)	56.80	0.83	47.29
20*	Organic meat and meat products (excl. poultry)			
21	Conventional poultry meat and poultry meat products	33.61	0.83	28.00
22*	Organic poultry meat and poultry meat products			
23	Fish and fish products	15.99	0.73	11.70
24	Conventional Fruit and vegetables	35.44	0.78	27.62
25	Organic Fruit and vegetables			

[38] Wiedmann, T., Wood, R., Lenzen, M., Minx, J., Guan, D. and Barrett, J. (2007) Development of an Embedded Carbon Emissions Indicator – Producing a Time Series of Input-Output Tables and Embedded Carbon Dioxide Emissions for the UK by Using a MRIO Data Optimisation System, Report to the UK Department for Environment, Food and Rural Affairs by Stockholm Environment Institute at the University of York and Centre for Integrated Sustainability Analysis at the University of Sydney. Defra, London, UK (not yet published). Available only for 1995 at the 76 sector level from ONS.

NACE industry		2004 Government intermediate expenditure on health - England (£ million)	Carbon intensity by NACE industry (kg/ £ spent)	2004 NACE industry CO_2 emissions (kt)
26	Vegetable and animal oils and fats	4.15	1.05	4.36
27	Dairy products (conventional)	51.43	0.85	43.78
28	Organic dairy products			
29	Grain mill products, starches and starch products	13.27	0.71	9.43
30	Prepared animal feeds	2.49	0.79	1.97
31	Bread, rusks and biscuits; manufacture of pastry goods and cakes (conventional)	50.60	0.67	33.68
32*	Organic bread, rusks and biscuits; manufacture of pastry goods and cakes			
33	Sugar	4.15	0.80	3.30
34	Cocoa, chocolate and sugar confectionery	51.43	0.52	26.92
35	Other food products	29.03	0.67	19.55
36	Alcoholic beverages	0.00	0.00	0.00
37	Production of mineral waters and soft drinks	0.00	0.00	0.00
38	Tobacco products	0.00	0.00	0.00
39	Preparation and spinning of textile fibres	0.00	0.00	0.00
40	Textile weaving	0.00	0.00	0.00
41	Finishing of textiles	0.00	0.00	0.00
42	Made-up textile articles, except apparel	43.96	0.97	42.64
43	Carpets and rugs	0.00	0.00	0.00
44	Other textiles	52.26	1.06	55.65
45	Knitted and crocheted fabrics and articles	0.00	0.00	0.00
46	Wearing apparel; dressing and dying of fur	209.03	0.62	130.19
47	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery and harness	0.00	0.00	0.00
48	Footwear	5.81	0.45	2.60
49	Wood and wood products, except furniture	0.00	0.00	0.00
50	Pulp	0.56	2.87	1.60
51	Paper and paperboard	136.31	2.61	356.11
52	Articles of paper and paperboard (except paper stationary)	292.05	1.23	358.13
53	Paper stationary	26.47	1.40	36.95
54	Paper-based publishing, printing and reproduction	383.50	0.55	212.77
55	Non paper-based publishing and reproduction of recorded media	13.82	0.70	9.70
56	Coke oven products	0.12	74.60	9.06
57	Refined petroleum products	154.66	2.01	310.42
58	Processing of nuclear fuel	6.97	0.98	6.83
59	Industrial gases	31.33	1.92	60.27
60	Dyes and pigments	47.47	1.92	91.27
61	Inorganic basic chemicals	0.00	0.00	0.00
62	Organic basic chemicals	0.00	0.00	0.00
63	Fertilisers and nitrogen compounds	0.00	0.00	0.00
64	Plastics and synthetic rubber in primary forms (non-PVC)	0.00	0.00	0.00
65	PVC plastics in primary forms	0.00	0.00	0.00
66	Pesticides and other agro-chemical	0.00	0.00	0.00

NACE industry		2004 Government intermediate expenditure on health - England (£ million)	Carbon intensity by NACE industry (kg/ £ spent)	2004 NACE industry CO_2 emissions (kt)
	products			
67	Paints, varnishes and similar coatings, printing ink and mastics	0.00	0.00	0.00
68	Pharmaceuticals, medicinal chemicals and botanical products	7575.60	0.54	4056.26
69	Soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations	131.89	0.84	111.38
70	Other chemical products	271.24	0.91	246.34
71	Man-made fibres	12.44	1.85	22.96
72	Rubber products	17.42	0.83	14.52
73	Plastic plates, sheets, tubes and profiles	149.32	0.93	138.83
74	Plastic packing goods	31.51	0.91	28.62
75	Glass and glass products	12.44	1.43	17.77
76	Ceramic goods	19.91	0.89	17.66
77	Bricks, tiles and other structural clay products for construction	12.44	1.60	19.87
78	Cement, lime and plaster	12.44	11.82	147.10
79	Articles of concrete, plaster and cement; cutting, shaping and finishing of stone; manufacture of other non-metallic products	18.25	1.37	24.92
80	Basic iron and steel and of ferro-alloys; manufacture of tubes and other first processing of iron and steel	0.00	0.00	0.00
81	Copper, Lead, Zinc, Tin and other basic precious and non-ferrous metals (not Aluminium)	0.00	0.00	0.00
82	Aluminium	0.00	0.00	0.00
83	Casting of metals	0.00	0.00	0.00
84	Structural metal products	14.10	1.24	17.53
85	Tanks, reservoirs and containers of metal; manufacture of central heating radiators and boilers; manufacture of steam generators	0.00	0.00	0.00
86	Forging, pressing, stamping and roll forming of metal; powder metallurgy; treatment and coating of metals	0.00	0.00	0.00
87	Cutlery, tools and general hardware	32.35	0.77	25.02
88	Other fabricated metal products	24.05	1.07	25.85
89	Machinery for the production and use of mechanical power, except aircraft, vehicle and cycle engines	0.00	0.00	0.00
90	Other general purpose machinery	0.00	0.00	0.00
91	Agricultural and forestry machinery	0.00	0.00	0.00
92	Machine tools	0.00	0.00	0.00
93	Other special purpose machinery	0.00	0.00	0.00
94	Weapons and ammunition	0.00	0.00	0.00
95	Domestic appliances (e.g. white goods)	0.00	0.00	0.00
96	Computers and other office machinery and equipment	201.56	0.47	94.52
97	Electric motors, generators and transformers; manufacture of electricity distribution and control apparatus	0.00	0.00	0.00

NACE industry		2004 Government intermediate expenditure on health - England (£ million)	Carbon intensity by NACE industry (kg/ £ spent)	2004 NACE industry CO_2 emissions (kt)
98	Insulated wire and cable	0.00	0.00	0.00
99	Electrical equipment not elsewhere classified	0.00	0.00	0.00
100	Electronic valves and tubes and other electronic components	0.00	0.00	0.00
101	Television and radio transmitters and line for telephony and line telegraphy	0.00	0.00	0.00
102	Television and radio receivers, sound or video recording or reproducing apparatus and associated goods	0.00	0.00	0.00
103	Medical, precision and optical instruments, watches and clocks	3751.72	0.44	1663.77
104	Motor vehicles, trailers and semi-trailers	4.98	0.79	3.94
105	Building and repairing of ships and boats	0.00	0.00	0.00
106	Railway transport equipment, motorcycles, bicycles and transport equipment n.e.c.	130.23	0.66	85.71
107	Aircraft and spacecraft	0.00	0.00	0.00
108	Furniture	97.88	0.84	82.70
109	Jewellery and related articles; manufacture of musical instruments	0.00	0.00	0.00
110	Sports goods, games and toys	0.00	0.00	0.00
111	Miscellaneous manufacturing not elsewhere classified; recycling	32.27	0.84	27.06
112	Recycling of metal waste and scrap	10.97	1.02	11.15
113	Recycling of non-metal waste	14.83	0.96	14.17
114	Electricity production - gas	80.99	9.39	760.22
115	Electricity production - coal	95.79	12.48	1195.61
116	Electricity production - nuclear	57.26	2.62	149.87
117	Electricity production - oil	3.31	3.65	12.06
118	Electricity production - renewables (and other)	10.67	9.76	104.09
119	Gas distribution	185.54	2.34	433.44
120	Steam and hot water supply	1.92	1.61	3.10
121	Collection, purification and distribution of water	65.53	0.52	34.31
122	Construction (other than commercial and domestic buildings)	57.31	0.41	23.76
123	Construction of commercial buildings	182.80	0.45	83.09
124	Construction of domestic buildings	104.13	0.43	44.99
125	Sale, maintenance and repair of motor vehicles, and motor cycles; retail sale of automotive fuel	51.39	0.40	20.41
126	Retail sale of automotive fuel	6.67	0.41	2.74
127	Wholesale trade and commission trade, except of motor vehicles and motor cycles	0.00	0.00	0.00
128	Retail trade, except of motor vehicles and motor cycles	0.00	0.00	0.00
129	Repair of personal and household goods	0.00	0.00	0.00
130	Hotels and accommodation	88.20	0.37	32.37
131	Restaurants, cafes, bars etc.	306.63	0.37	114.54
132	Passenger transport by railways	59.56	0.63	37.31
133	Freight transport by inter-urban railways	26.71	0.64	17.00

NACE industry		2004 Government intermediate expenditure on health - England (£ million)	Carbon intensity by NACE industry (kg/ £ spent)	2004 NACE industry CO_2 emissions (kt)
134	Buses and coaches	21.67	4.38	94.94
135	Tubes and Trams	146.88	0.41	60.95
136	Taxis operation	22.03	2.16	47.64
137	Freight transport by road	550.34	1.09	599.35
138	Transport via pipeline	3.11	0.91	2.83
139	Passenger sea and coastal water transport + Passenger inland water transport	0.06	3.75	0.24
140	Freight sea and coastal water transport + Other inland water transport	8.23	3.73	30.68
141	Passenger air transport	0.70	3.37	2.37
142	Freight and other air transport	19.21	3.21	61.59
143	Supporting and auxiliary transport activities: travel agencies, cargo handling, storage, etc.	29.03	0.27	7.84
144	Postal and courier services	137.69	0.37	51.40
145	Telecommunications	405.61	0.28	113.56
146	Banking and financial intermediation, except insurance and pension funding	12.44	0.32	3.99
147	Insurance and pension funding, except compulsory social security	349.21	0.29	100.02
148	Auxiliary financial services	0.00	0.00	0.00
149	Real estate activities with own property; letting of own property, except dwellings	477.78	0.15	70.36
150	Letting of dwellings, including imputed rent	0.00	0.00	0.00
151	Real estate agencies or activities on a fee or contract basis	0.00	0.00	0.00
152	Renting of cars and other transport equipment	215.06	0.33	71.63
153	Renting of machinery and equipment, excl. office machinery and computers	148.93	0.34	50.60
154	Renting of office machinery and equipment including computers	14.76	0.25	3.68
155	Renting of personal and household goods	33.49	0.27	8.98
156	Computer services and related activities	499.34	0.20	98.68
157	Research and development	577.32	0.33	189.85
158	Legal activities	766.44	0.13	99.31
159	Accounting, book-keeping and auditing activities; tax consultancy	140.18	0.14	20.09
160	Business and management consultancy activities; management activities; market research and public opinion polling	26.54	0.20	5.26
161	Technical consultancy; technical testing and analysis; architectural and engineering related activities	846.07	0.17	142.45
162	Advertising	275.39	0.27	74.17

NACE industry		2004 Government intermediate expenditure on health - England (£ million)	Carbon intensity by NACE industry (kg/ £ spent)	2004 NACE industry CO_2 emissions (kt)
163	Other business services	791.32	0.18	140.20
164	Public administration (not defence); compulsory social security	0.00	0.00	0.00
165	Public administration - defence	0.00	0.00	0.00
166	Primary, secondary and other education	14.10	0.25	3.53
167	Higher-level education	9.12	0.17	1.57
168	Human health and veterinary activities	5436.38	0.26	1392.31
169	Social work activities	457.04	0.30	135.61
170	Collection and treatment of sewage and liquid waste	154.91	0.50	76.87
171	Collection and treatment of solid and other waste (excl. waste incineration)	154.23	0.48	73.26
172	Waste incineration	11.30	0.49	5.50
173	Sanitation, remediation and similar activities	27.11	0.63	17.09
174	Activities of membership organisations	0.00	0.00	0.00
175	Recreational and cultural activities	66.19	0.23	15.51
176	Sporting and other activities	10.13	0.23	2.30
177	Dry cleaning, hair dressing, funeral parlours and other service activities	166.72	0.29	47.85
178	Private households as employers of domestic staff	0.00	0.00	0.00
Total from 178 sectors		**28,479.22**	**0.55 (average)**	**15,624.64**

***** Organic sectors are merged with the equivalent conventional sector due to uncertainties in the organic estimates

Appendix B1.2: Travel emission estimates

In this Appendix estimates of emissions from patient, visitor and staff commuting travel are estimated. These emissions are then added to those calculated from the business/fleet/patient transport services (PTS) travel emissions which are obtained from the Input-Output model.

The main data source for estimates of distances travelled for patient/visitor/staff commuting travel is the Transport Statistics Bulletin: National Travel Survey 2006, Department for Transport. The main assumptions are:

- NHS Staff commuting – Distance and modes of travel can be taken from 'commuting' e.g. in Tables 4.1/ 7.2
- Visitor/patient travel – Distance and modes of travel can be taken from 'personal business' e.g. in Table 7.2. However, visitor/patient travel is a subset of 'personal business', and the further

breakdown of the 'personal business' section as set out below was supplied by e-mail from the national.travelsurvey@dft.gsi.gov.uk on 02 Feb 2008

(a) Basic NTS data - Trips and distance per person per year by purpose, 2004		
Purpose:	**Trips per person per year**	**Distance per person per year (miles)**
Personal business medical	18	70
Other social [1]	16	123
Escort shopping/ pers. business	35	141
[1] Other social refers to meeting friends outside of a private home, not for food/drink.		

(b) NHS patient/visitor transport (kms) estimated from NTS data

2004 NTS data - used for NHS travel Category	trips/yr	distance (miles)	distance (kms)	distance / trip (km)
personal business – medical [1]	16.0	62.2	99.6	6.2
other social - visit friends (i.e. in hospital) [2]	2.0	15.4	24.6	12.3
escort - passenger to hospital visit [3]	4.0	0.0	0.0	0.0
Total NHS related patient/visitor travel	**22.0**	**77.6**	**124.2**	**5.6**

[1] It is assumed that 90% (in this case 16 trips per year) are to NHS premises. The other 10% (in this case 2 trips/year) are for non NHS i.e. private healthcare (eg private eye tests, private dental check up)
[2] Most trips are for visit friends - social. Thus it is assumed that 10% (in this case 2 trips per year) are for visiting friends eg. In NHS premises e.g. hospitals
[3] Most escort trips are as passengers for shopping/other activities. Thus it is assumed that 10% (in this case 4 trips/year) are visiting friends as a passenger to NHS premises e.g. Hospitals

(c) England & UK population data

	Population (mid 2004)
England	50,093,800
United Kingdom	59,834,900

Source: Office for National Statistics

(d) CO_2 Conversion factor

Mode	Walk	Bicycle	Car driver	Car passenger	Motor-cycle	Other private	Local stage bus	Surface rail/ underground	Other public	Total
Distance travelled (miles/ thousands)	15.72	1.80	248.02	129.05	1.97	9.19	19.14	21.06	7.75	453.70
Proportion	0.03	0.00	0.55	0.28	0.00	0.02	0.04	0.05	0.02	1.00
Conversion factor	0.00	0.00	0.256*	0.29	0.23	0.23	0.26	0.07	0.72	0.25

Sources: distance travelled for personal business from NTS 2004 table 7.2

Conversion factors, which include both direct and indirect impacts, from REAP model, SEI

*This is from direct carbon conversion factor from DEFRA (0.18 kg/km) plus indirect car conversion factor from REAP SEI (0.076kg/km)

(e) Estimation of NHS patient/visitor travel emissions (2004)

Population of England	50,093,800	no
NHS related travel/person	149.92	kms
total travel distance	7,510,099,440.90	kms
CO_2 conversion factor	0.25	kg/km
Total CO_2 emissions	**1,911,574.91**	**Tes (CO_2)**

(f) Estimation of NHS staff commuting travel emissions (2004)

Number of NHS staff	1,300,000	no
No of commuting trips/yr	168.00	per year
distance per person/yr	2,284.80	kms/yr
Total commute distance	2,970,240,000.00	kms/yr
CO_2 conversion factor	0.25	kg/km
Total CO_2 emissions	**756,026.78**	**Tes (CO_2)**

(g) Estimation of NHS patient/staff/visitor travel emissions (2004)

NHS patient/visitor distance	7,510,099,440.90	kms
NHS staff commuting distance	2,970,240,000.00	kms
TOTAL distance travelled	10,480,339,440.90	kms
NHS patient/visitor emissions	1,911,574.91	Tes (CO_2)
NHS staff commuting emissions	756,026.78	Tes (CO_2)
TOTAL emissions	**2,667,601.69**	**Tes (CO_2)**

Appendix B1.3: Building emission estimates

(a) Basic data from ERIC 2004-2005 (totals) and estimation of NHS building energy use emissions (2004-2005)

NHS energy use (ERIC data)			NHS building energy emissions	
Utility electricity	11,032,005.00	GJ	1,743,875,316.43	kg CO_2
Utility gas	29,132,753.00	GJ	1,537,684,968.85	kg CO_2
Utility oil	2,252,095.00	GJ	168,920,637.57	kg CO_2
Utility coal	1,730,794.00	GJ	153,860,663.42	kg CO_2
Local electricity	545,299.00	GJ	86,197,700.80	kg CO_2
Local steam	1,775,423.00	GJ	93,710,376.79	kg CO_2
Local hot water	625,340.00	GJ	33,006,695.88	kg CO_2
Utility electricity	3,064,690,989.00	kWh	1,743,875.32	Tonnes CO_2
Utility gas	8,093,078,783.40	kWh	1,537,684.97	Tonnes CO_2
Utility oil	625,631,991.00	kWh	168,920.64	Tonnes CO_2
Utility coal	480,814,573.20	kWh	153,860.66	Tonnes CO_2
Local electricity	151,484,062.20	kWh	86,197.70	Tonnes CO_2
Local steam	493,212,509.40	kWh	93,710.38	Tonnes CO_2
Local hot water	173,719,452.00	kWh	33,006.70	Tonnes CO_2

(b) Energy Conversion factors from Defra

The data below shows the energy conversion factors (Defra, 2005) used in the analysis, as well as the conversion factors (Defra, 2007) used in the Carbon Emissions Modelling to 2020 analysis. The use of the latter factors gives slightly higher building energy emissions in the second study.

Energy source	Data Source			
	DEFRA (2005)[39]		DEFRA (2007)[40]	
Electricity, gas, and other fuels*	0.57	kg CO_2/ kWh	0.57	kg CO_2/ kWh
Gas	0.19	kg CO_2/ kWh	0.21	kg CO_2/ kWh
Oil	0.27	kg CO_2/ kWh	0.27	kg CO_2/ kWh
Coal	0.32	kg CO_2/ kWh	0.35	kg CO_2/ kWh
Local electricity*	0.57	kg CO_2/ kWh	0.57	kg CO_2/ kWh
Local steam*	0.19	kg CO_2/ kWh	0.21	kg CO_2/ kWh
Local hot water*	0.19	kg CO_2/ kWh	0.21	kg CO_2/ kWh

* taken from REAP/ SEI conversion factors

Appendix B1.4: NHS energy mix

(a) On-site energy use proportional to gas, coal and oil

Energy type	GJ	Energy mix
Gas	29,132,753	0.88
Coal	1,730,794	0.05
Oil	2,252,095	0.07

Data from ERIC - GJ consumed 2004-05.

[39] DEFRA (2005). Guidelines for company reporting on Greenhouse gas emissions, available at http://www.defra.gov.uk/environment/business/reporting/pdf/envrpgas-annexes.pdf

[40] DEFRA (2007). Guidelines to Defra's greenhouse gas (GHG) conversion factors for company reporting, available at http://www.defra.gov.uk/environment/business/reporting/pdf/conversion-factors.pdf

Appendix B1.5: Calculation of comparative CO_2 emissions

(a) Total CO_2 emissions England/ UK (for 2004)

Total CO_2 emissions England	593.99	Mt CO_2
Total CO_2 emissions NI	18.87	Mt CO_2
Total CO_2 emissions Wales	32.92	Mt CO_2
Total CO_2 emissions Scotland	60.07	Mt CO_2
Total CO_2 emissions UK	705.85	Mt CO_2

(b) Total CO_2 emissions government spending England/ UK (for 2004)

Total CO_2 emissions England	63.06	Mt CO_2
Total CO_2 emissions UK	75.32	Mt CO_2

Source: Stockholm Environment Institute (2008) SRIO model

(c) NHS CO_2 emissions England (2004)

CO_2 emissions	18,610,678.30	tCO_2
CO_2 emissions	18.61	Mt CO_2

(d) NHS CO_2 emissions England, excluding staff/ visitor/ patient travel emission (2004)

CO_2 emissions	15,943,076.61	tCO_2
CO_2 emissions	15.94	Mt CO_2

These emissions are assigned to households, and therefore not comparable to government spending

(e) Comparisons CO_2 emissions

NHS England emissions as a percentage of total England emissions	3.13%
NHS England emissions as a percentage of total NI emissions	99%
NHS England emissions as a percentage of total Wales emissions	57%
NHS England emissions as a percentage of total Scotland emissions	31%
NHS England emissions as percentage of total UK emissions	2.64%

NHS emissions (excluding travel) as a percentage of government emissions in England	25.28%
NHS emissions (excluding travel) as a percentage of UK government emissions	21.17%

(f) UK Consumption emissions

For comparison to NHS England consumption emissions, a value of 706MtCO_2 for UK consumption emission has been used by the SEI. This value has been calculated by the SEI using a single regional input-output model. This approach is considered valid for our comparative purposes in this report as consumption emissions include imports, whilst excluding exports. As the UK exports less goods and services than it imports, it seems consistent that the SEI has calculated consumption emissions which are higher than the production emissions.

APPENDIX B2: DATA TABLES FOR CHARTS

B2.1. Carbon Footprint of NHS England 2004

Direct Emissions (Scope 1)	2,564,061.49 tCO_2	14%
Electricity (Scope 2)	2,311,148.66 tCO_2	12%
Indirect Emissions (Scope 3)	13,735,468.15 tCO_2	74%

B2.2. Primary sector breakdown of NHS England carbon footprint 2004

	CO_2 emissions	
	tCO_2	% of total
Travel	3,405,907.55	18%
Building energy use	4,136,904.28	22%
Procurement	11,067,866.46	59%

B2.3. Secondary sector breakdown of NHS England carbon footprint 2004

Sector	**Sub sector**	**CO_2 emissions**	
		tCO_2	% of total
Travel	Patients, visitors and staff commute: own travel	2,667,601.69	14%
	NHS transport: business mileage/fleet/PTS	738,305.86	4%
	Travel: sub total	**3,405,907.55**	**18%**
Building energy use	Electricity: direct and indirect emissions	2,311,148.66	12%
	On-site gas	1,658,299.13	9%
	On-site coal	72,769.47	0%
	On-site oil	94,687.03	1%
	Building energy use: sub total	**4,136,904.28**	**22%**
Procurement	NHS Freight transport	719,296.94	4%
	Pharmaceuticals	4,056,260.77	22%
	Medical Instruments /equipment	1,663,771.65	9%
	Social work activities	135,612.08	1%
	Paper products/ stationary	965,556.40	5%
	Business Services	977,323.72	5%
	Manufactured fuels/ chemicals/ gases	526,795.01	3%
	Other manufactured products	632,070.15	3%
	Food & catering	394,916.89	2%
	Construction	361,263.89	2%
	Information and Communication Technologies (ICT)	320,145.84	2%
	Water & sanitation	128,275.38	1%
	Waste products & recycling	104,091.66	1%
	Other procurement	82,486.10	0%
	Procurement: sub total	**11,067,866.46**	**59%**
Total NHS England emissions		**18,610,678.30**	**100%**

B2.4. Total emissions over time for the three main sectors of travel, energy and procurement

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Travel	3.07	2.98	2.93	3.01	3.09	3.16	3.38	3.38	3.31	3.31	3.22	3.48	3.41
Building energy use	4.75	4.01	4.09	3.94	4.08	3.32	3.45	3.84	3.72	3.94	3.59	3.97	4.14
Procurement	8.76	8.48	8.50	8.52	8.75	8.92	8.94	9.40	9.49	10.71	10.51	10.91	11.07

B2.5. Emissions by sub-sector from 1992 to 2004

		1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Travel	Patients, visitors and staff commute: own travel	2.26	2.23	2.21	2.31	2.36	2.47	2.69	2.71	2.70	2.65	2.55	2.75	2.67
	NHS transport: business mileage/fleet/PTS	0.81	0.75	0.73	0.70	0.74	0.68	0.69	0.67	0.60	0.66	0.67	0.73	0.74
	Transport: sub total	***3.07***	***2.98***	***2.93***	***3.01***	***3.09***	***3.16***	***3.38***	***3.38***	***3.31***	***3.31***	***3.22***	***3.48***	***3.41***
Building energy use	Electricity: direct and indirect emissions	3.52	3.04	3.08	2.94	2.89	2.32	2.34	2.43	2.31	2.31	1.95	2.21	2.31
	On-site gas, coal and oil	1.23	0.96	1.00	1.01	1.19	1.00	1.11	1.41	1.40	1.63	1.64	1.77	1.83
	Building energy use: sub total	***4.75***	***4.01***	***4.09***	***3.94***	***4.08***	***3.32***	***3.45***	***3.84***	***3.72***	***3.94***	***3.59***	***3.97***	***4.14***
Procurement	NHS Freight transport	0.70	0.67	0.67	0.63	0.66	0.60	0.63	0.68	0.70	0.75	0.71	0.71	0.72
	Pharmaceuticals	2.72	2.81	2.98	3.09	2.89	3.18	2.90	3.25	3.18	3.96	4.18	4.20	4.06
	Medical Instruments /equipment	1.21	1.19	1.10	1.19	1.36	1.39	1.45	1.54	1.56	1.74	1.68	1.66	1.66
	Social work activities	0.08	0.08	0.07	0.07	0.09	0.09	0.11	0.11	0.10	0.11	0.10	0.11	0.14
	Paper products/ stationary	0.68	0.62	0.62	0.60	0.62	0.61	0.69	0.65	0.72	0.77	0.73	0.89	0.97
	Business Services	0.74	0.70	0.71	0.72	0.79	0.77	0.89	0.87	0.83	0.91	0.88	0.92	0.98
	Manufactured fuels/ chemicals/ gases	0.43	0.41	0.40	0.37	0.36	0.37	0.33	0.32	0.37	0.44	0.40	0.50	0.53
	Other	0.55	0.50	0.49	0.45	0.46	0.48	0.48	0.51	0.56	0.59	0.50	0.57	0.63

	manufactured products													
	Food & catering	0.62	0.53	0.54	0.51	0.52	0.47	0.43	0.45	0.44	0.42	0.39	0.38	0.39
	Construction	0.36	0.35	0.34	0.33	0.41	0.40	0.42	0.40	0.39	0.39	0.35	0.36	0.36
	Information and Communication Technologies (ICT)	0.28	0.25	0.25	0.24	0.25	0.26	0.26	0.27	0.30	0.32	0.29	0.30	0.32
	Water & sanitation	0.16	0.14	0.13	0.14	0.14	0.12	0.15	0.15	0.14	0.14	0.12	0.13	0.13
	Waste products & recycling	0.15	0.13	0.11	0.11	0.12	0.10	0.12	0.11	0.10	0.10	0.09	0.10	0.10
	Other procurement	0.09	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.08	0.07	0.08	0.08
	Procurement: sub total	***8.76***	***8.48***	***8.50***	***8.52***	***8.75***	***8.92***	***8.94***	***9.40***	***9.49***	***10.71***	***10.51***	***10.91***	***11.07***
Total NHS England emissions		**16.58**	**15.46**	**15.52**	**15.48**	**15.93**	**15.40**	**15.77**	**16.62**	**16.51**	**17.97**	**17.33**	**18.36**	**18.62**

B2.6. Change in emissions for each sector 1992 – 2004

	Change Mt CO_2	Percentage change
Travel: Patient travel	0.20	119%
Travel: Visitors	0.04	107%
Travel: Staff commute	0.17	129%
Travel: NHS transport: business mileage/fleet/PTS	-0.07	91%
Building energy use: Electricity: direct and indirect emissions	-1.20	66%
Building energy use: On-site gas, coal and oil	0.59	148%
Procurement: NHS Freight transport	0.02	103%
Procurement: Pharmaceuticals	1.34	149%
Procurement: Medical Instruments /equipment	0.46	138%
Procurement: Social work activities	0.05	165%
Procurement: Paper products/ stationary	0.28	142%
Procurement: Business Services	0.24	132%
Procurement: Manufactured fuels/ chemicals/ gases	0.10	123%
Procurement: Other manufactured products	0.08	115%
Procurement: Food & catering	-0.23	63%
Procurement: Construction	0.00	101%
Procurement: Information and Communication Technologies (ICT)	0.05	116%
Procurement: Water & sanitation	-0.03	79%
Procurement: Waste products & recycling	-0.05	67%
Procurement: Other procurement	0.00	96%

B2.7. Changes in expenditure, emissions and carbon intensity of production of the NHS England

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Expenditure £ million	15,642	14,764	15,677	15,718	16,791	16,485	18,063	20,471	20,975	22,475	24,117	25,834	28,760
Emissions (kt)	14,232	13,144	13,225	13,084	13,487	12,838	12,999	13,829	13,722	15,232	14,690	15,523	15,847
Carbon intensity (kt CO_2/ £ million)	0.91	0.89	0.84	0.83	0.80	0.78	0.72	0.68	0.65	0.68	0.61	0.60	0.55

B2.8. Changes in expenditure, emissions and carbon intensity of production of NHS energy use

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Expenditure £ million	2,871	2,377	2,579	2,609	3,076	2,692	3,086	3,902	3,966	4,249	4,781	5,258	5,872
Emissions (kt)	4,749	4,006	4,086	3,945	4,082	3,319	3,451	3,844	3,716	3,944	3,592	3,973	4,287
Carbon intensity (kt CO_2/ £ million)	1.65	1.69	1.58	1.51	1.33	1.23	1.12	0.99	0.94	0.93	0.75	0.76	0.73

B2.9. Changes in expenditure, emissions and carbon intensity of production of the NHS procurement

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Expenditure £ million	12,248	11,902	12,577	12,611	13,196	13,282	14,426	15,979	16,404	17,570	18,660	19,840	22,074
Emissions (kt)	8,761	8,477	8,498	8,525	8,754	8,921	8,941	9,400	9,490	10,713	10,510	10,908	11,476
Carbon intensity (kt CO_2/ £ million)	0.72	0.71	0.68	0.68	0.66	0.67	0.62	0.59	0.58	0.61	0.56	0.55	0.52

B2.10. Carbon footprint of the pharmaceutical and medical instrument industries (kt) 2004

	Pharmaceuticals	Medical Instruments
On-site emissions	2,590	348
Electricity	876	843
Indirect emissions	590	472

B2.11. NHS spending on pharmaceutical products by origin and NHS embedded emissions from pharmaceutical products by origin 2004

*This data uses a multi-regional input-output model compared with a single region model used throughout the report (this was an extension to the project when the data became available). This accounts for production technologies abroad, therefore, emissions embedded in pharmaceuticals is increased as production outwith OECD Europe is more carbon intensive.

	Pharmaceuticals produced domestically	Pharmaceuticals imported from OECD Europe	Pharmaceuticals imported from non-Europe OECD	Pharmaceuticals imported from non-OECD
Expenditure (£million)	1,913	4,000	366	1,311
Embedded CO_2 emissions (kt)	1,174	1,912	444	3,459
Carbon intensity (kg CO_2/ £)	0.61	0.48	1.21	2.64

B2.12. NHS spending on medical products by origin and NHS embedded emissions from medical products by origin 2004

	Medical instruments produced domestically	Medical instruments imported from OECD Europe	Medical instruments imported from non-Europe OECD	Medical instruments imported from non-OECD
Expenditure (£million)	1,990	661	116	733
Embedded CO_2 emissions (kt)	1,043	148	57	1,047
Carbon intensity (kg CO_2/ £)	0.52	0.22	0.49	1.43

*this data uses a multi-regional input-output model compared with a single region model used throughout the report (this was an extension to the project when the data became available). This accounts for production technologies abroad, therefore, emissions embedded in medical instruments is increased as production outwith OECD Europe is more carbon intensive.

B2.13. Changes in expenditure, emissions and efficiency of production of the Pharmaceutical industry

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Expenditure £ million	4063	4025	4276	4300	4355	4321	4378	5193	5444	5950	6595	6924	7576
Emissions (kt)	2,715	2,814	2,981	3,091	2,893	3,176	2,900	3,252	3,178	3,960	4,180	4,197	4,056
Carbon intensity (kt CO_2/ £ million)	0.67	0.70	0.70	0.72	0.66	0.74	0.66	0.63	0.58	0.67	0.63	0.61	0.54

B2.14. Changes in expenditure, emissions and efficiency of production of the Medical Instrument industry

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Expenditure £ million	1,844	1,833	1,857	2,023	2,244	2,325	2,596	2,999	3,040	3,317	3,365	3,454	3,752
Emissions (kt)	1,207	1,190	1,097	1,193	1,361	1,388	1,449	1,544	1,559	1,738	1,685	1,660	1,664
Carbon intensity (kt CO_2/ £ million)	0.65	0.65	0.59	0.59	0.61	0.60	0.56	0.51	0.51	0.52	0.50	0.48	0.44

APPENDIX B3: CHANGE IN CARBON INTENSITY BY SECTOR 1992 – 2004 (KG CO_2/ £ SPENT)

No	Industries (NACE)	1992	2004	Percentage change
1	Growing of cereals, vegetables, fruits and other crops	0.99	0.84	85%
2				
3	Growing of horticulture specialities and nursery products	0.94	0.97	102%
4	Farming of livestock (except poultry)	0.98	0.84	86%
5				
6	Farming of poultry	0.96	0.91	95%
7				
8	Forestry, logging and related service activities (conventional)	-	-	0%
9	Forestry and logging and related service activities ('sustainable' / FSC)	-	-	0%
10	Fishing	-	-	0%
11	Fish farming (non-organic)	-	-	0%
12	Fish farming (organic/sustainable)	-	-	0%
13	Mining of coal and lignite; extraction of peat	0.84	0.99	118%
14	Extraction of crude petroleum and natural gas and Service activities incidental to oil and gas extraction, excluding surveying	-	-	0%
15	Mining of uranium and thorium ores	-	-	0%
16	Mining of iron ores	-	-	0%
17	Mining of non-ferrous metal ores, except uranium and thorium ores	-	-	0%
18	Mining and quarrying of stone, gravel, clays, salt, etc.	-	-	0%
19	Meat and meat products (excl. poultry)	1.03	0.83	81%
20				
21	Poultry meat and poultry meat products	1.03	0.83	81%
22				
23	Fish and fish products	0.95	0.73	77%
24	Fruit and vegetables	0.95	0.78	82%
25				
26	Vegetable and animal oils and fats	1.32	1.05	80%
27	Dairy products	1.05	0.85	81%
28				
29	Grain mill products, starches and starch products	0.99	0.71	72%
30	Prepared animal feeds	1.02	0.79	78%
31	Bread, rusks and biscuits; manufacture of pastry goods and cakes	0.85	0.67	78%
32				
33	Sugar	0.85	0.80	94%
34	Cocoa, chocolate and sugar confectionery	0.83	0.52	63%
35	Other food products	0.92	0.67	73%
36	Alcoholic beverages	-	-	0%
37	Production of mineral waters and soft drinks	-	-	0%
38	Tobacco products	-	-	0%
39	Preparation and spinning of textile fibres	-	-	0%
40	Textile weaving	-	-	0%
41	Finishing of textiles	-	-	0%
42	Made-up textile articles, except apparel	1.01	0.97	96%
43	Carpets and rugs	-	-	0%
44	Other textiles	1.13	1.06	94%
45	Knitted and crocheted fabrics and articles	-	-	0%
46	Wearing apparel; dressing and dying of fur	0.72	0.62	87%
47	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery and harness	-	-	0%
48	Footwear	0.60	0.45	74%
49	Wood and wood products, except furniture	-	-	0%
50	Pulp	3.29	2.87	87%
51	Paper and paperboard	3.37	2.61	78%

No	Industries (NACE)	1992	2004	Percentage change
52	Articles of paper and paperboard (except paper stationary)	1.39	1.23	88%
53	Paper stationary	1.66	1.40	84%
54	Paper-based publishing, printing and reproduction	0.70	0.55	80%
55	Non paper-based publishing and reproduction of recorded media	1.10	0.70	64%
56	Coke oven products	91.94	74.60	81%
57	Refined petroleum products	2.92	2.01	69%
58	Processing of nuclear fuel	1.45	0.98	67%
59	Industrial gases	2.30	1.92	84%
60	Dyes and pigments	2.30	1.92	84%
61	Inorganic basic chemicals	-	-	0%
62	Organic basic chemicals	-	-	0%
63	Fertilisers and nitrogen compounds	-	-	0%
64	Plastics and synthetic rubber in primary forms (non-PVC)	-	-	0%
65	PVC plastics in primary forms	-	-	0%
66	Pesticides and other agro-chemical products	-	-	0%
67	Paints, varnishes and similar coatings, printing ink and mastics	-	-	0%
68	Pharmaceuticals, medicinal chemicals and botanical products	0.67	0.54	80%
69	Soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations	0.81	0.84	104%
70	Other chemical products	1.25	0.91	73%
71	Man-made fibres	2.50	1.85	74%
72	Rubber products	1.04	0.83	80%
73	Plastic plates, sheets, tubes and profiles	1.27	0.93	73%
74	Plastic packing goods	1.26	0.91	72%
75	Glass and glass products	2.02	1.43	71%
76	Ceramic goods	1.17	0.89	76%
77	Bricks, tiles and other structural clay products for construction	2.85	1.60	56%
78	Cement, lime and plaster	12.18	11.82	97%
79	Articles of concrete, plaster and cement; cutting, shaping and finishing of stone; manufacture of other non-metallic products	1.97	1.37	69%
80	Basic iron and steel and of ferro-alloys; manufacture of tubes and other first processing of iron and steel	-	-	0%
81	Copper, Lead, Zinc, Tin and other basic precious and non-ferrous metals (not Aluminium)	-	-	0%
82	Aluminium	-	-	0%
83	Casting of metals	-	-	0%
84	Structural metal products	1.46	1.24	85%
85	Tanks, reservoirs and containers of metal; manufacture of central heating radiators and boilers; manufacture of steam generators	-	-	0%
86	Forging, pressing, stamping and roll forming of metal; powder metallurgy; treatment and coating of metals	-	-	0%
87	Cutlery, tools and general hardware	1.30	0.77	59%
88	Other fabricated metal products	1.45	1.07	74%
89	Machinery for the production and use of mechanical power, except aircraft, vehicle and cycle engines	-	-	0%
90	Other general purpose machinery	-	-	0%
91	Agricultural and forestry machinery	-	-	0%
92	Machine tools	-	-	0%
93	Other special purpose machinery	-	-	0%
94	Weapons and ammunition	-	-	0%
95	Domestic appliances (e.g. white goods)	-	-	0%
96	Computers and other office machinery and equipment	0.62	0.47	76%
97	Electric motors, generators and transformers; manufacture of electricity distribution and control apparatus	-	-	0%
98	Insulated wire and cable	-	-	0%
99	Electrical equipment not elsewhere classified	-	-	0%
100	Electronic valves and tubes and other electronic components	-	-	0%
101	Television and radio transmitters and line for telephony and line	-	-	0%

No	Industries (NACE)	1992	2004	Percentage change
	telegraphy			
102	Television and radio receivers, sound or video recording or reproducing apparatus and associated goods	-	-	0%
103	Medical, precision and optical instruments, watches and clocks	0.65	0.44	68%
104	Motor vehicles, trailers and semi-trailers	1.04	0.79	76%
105	Building and repairing of ships and boats	-	-	0%
106	Railway transport equipment, motorcycles, bicycles and transport equipment n.e.c.	1.24	0.66	53%
107	Aircraft and spacecraft	-	-	0%
108	Furniture	1.13	0.84	75%
109	Jewellery and related articles; manufacture of musical instruments	-	-	0%
110	Sports goods, games and toys	-	-	0%
111	Miscellaneous manufacturing not elsewhere classified; recycling	1.30	0.84	64%
112	Recycling of metal waste and scrap	3.33	1.02	31%
113	Recycling of non-metal waste	3.32	0.96	29%
114	Electricity production - gas	4.29	9.39	219%
115	Electricity production - coal	14.91	12.48	84%
116	Electricity production - nuclear	4.61	2.62	57%
117	Electricity production - oil	11.93	3.65	31%
118	Electricity production - renewables (and other)	6.25	9.76	156%
119	Gas distribution	0.99	2.34	237%
120	Steam and hot water supply	1.34	1.61	120%
121	Collection, purification and distribution of water	0.60	0.52	88%
122	Construction (other than commercial and domestic buildings)	0.75	0.41	55%
123	Construction of commercial buildings	0.71	0.45	64%
124	Construction of domestic buildings	0.66	0.43	66%
125	Sale, maintenance and repair of motor vehicles, and motor cycles; retail sale of automotive fuel	0.56	0.40	71%
126	Retail sale of automotive fuel	0.52	0.41	79%
127	Wholesale trade and commission trade, except of motor vehicles and motor cycles	-	-	0%
128	Retail trade, except of motor vehicles and motor cycles	-	-	0%
129	Repair of personal and household goods	-	-	0%
130	Hotels and accommodation	0.60	0.37	61%
131	Restaurants, cafes, bars etc.	0.60	0.37	62%
132	Passenger transport by railways	0.98	0.63	64%
133	Freight transport by inter-urban railways	0.99	0.64	65%
134	Buses and coaches	10.20	4.38	43%
135	Tubes and Trams	0.59	0.41	71%
136	Taxis operation	2.17	2.16	100%
137	Freight transport by road	1.25	1.09	87%
138	Transport via pipeline	2.99	0.91	30%
139	Passenger sea and coastal water transport + Passenger inland water transport	4.97	3.75	75%
140	Freight sea and coastal water transport + Other inland water transport	4.83	3.73	77%
141	Passenger air transport	3.21	3.37	105%
142	Freight and other air transport	3.09	3.21	104%
143	Supporting and auxiliary transport activities: travel agencies, cargo handling, storage, etc.	0.34	0.27	80%
144	Postal and courier services	0.31	0.37	119%
145	Telecommunications	0.36	0.28	78%
146	Banking and financial intermediation, except insurance and pension funding	0.49	0.32	66%
147	Insurance and pension funding, except compulsory social security	0.51	0.29	56%
148	Auxiliary financial services	-	-	0%
149	Real estate activities with own property; letting of own property, except dwellings	0.31	0.15	48%
150	Letting of dwellings, including imputed rent	-	-	0%

No	Industries (NACE)	1992	2004	Percentage change
151	Real estate agencies or activities on a fee or contract basis	-	-	0%
152	Renting of cars and other transport equipment	0.57	0.33	59%
153	Renting of machinery and equipment, excl. office machinery and computers	0.56	0.34	61%
154	Renting of office machinery and equipment including computers	0.62	0.25	40%
155	Renting of personal and household goods	0.60	0.27	44%
156	Computer services and related activities	0.40	0.20	50%
157	Research and development	0.41	0.33	79%
158	Legal activities	0.21	0.13	62%
159	Accounting, book-keeping and auditing activities; tax consultancy	0.19	0.14	74%
160	Business and management consultancy activities; management activities; market research and public opinion polling	-	0.20	
161	Technical consultancy; technical testing and analysis; architectural and engineering related activities	0.29	0.17	57%
162	Advertising	0.45	0.27	60%
163	Other business services	0.32	0.18	55%
164	Public administration (not defence); compulsory social security	-	-	0%
165	Public administration - defence	-	-	0%
166	Primary, secondary and other education	0.40	0.25	63%
167	Higher-level education	0.46	0.17	38%
168	Human health and veterinary activities	0.45	0.26	57%
169	Social work activities	0.52	0.30	57%
170	Collection and treatment of sewage and liquid waste	0.66	0.50	75%
171	Collection and treatment of solid and other waste (excl. waste incineration)	1.02	0.48	47%
172	Waste incineration	1.02	0.49	48%
173	Sanitation, remediation and similar activities	1.29	0.63	49%
174	Activities of membership organisations	-	-	0%
175	Recreational and cultural activities	0.49	0.23	48%
176	Sporting and other activities	0.50	0.23	46%
177	Dry cleaning, hair dressing, funeral parlours and other service activities	0.48	0.29	59%
178	Private households as employers of domestic staff	-	-	0%
Average		**0.91**	**0.55**	**60%**

APPENDIX B4: HOW DO WE MEASURE THE INDIRECT EMISSIONS ALONG THE SUPPLY CHAIN?

From environmental accounts we have the direct CO_2 emissions of each sector in the UK. National accounts give us the transactions between sectors. Combining these two data sets we are able to calculate the tonnes of CO_2 emitted per pound spent for all sectors. This is a measure of the production efficiency of different industries (giving an average efficiency for all UK industries). Using the expenditure profile of the pharmaceutical industry combined with industry efficiencies, we can calculate the indirect emissions associated with the pharmaceutical supply chain.

Taking the example of one supplier to the pharmaceutical industry– paper and paper board (layer 3 in figure 11) – we can calculate the emissions embedded in paper products purchased by the pharmaceutical industry. We know how much money the pharmaceutical industry spends on the paper industry in order to supply pharmaceuticals to the NHS. From this we can calculate the emissions attached to the paper products purchased by multiplying the expenditure by the efficiency of the paper industry. So for example, the pharmaceutical industry spends £3 on paper products for every £100 spent. Paper products have an average efficiency of production of 2.7 kt/ £ million spent. Therefore, for every £100 spent by the pharmaceutical

industry, the embedded emissions of the paper industry supplying the pharmaceutical industry are 0.014 tonnes CO_2.

In capturing the whole supply chain of the pharmaceutical industry, we know what the paper industry spends on other products. We can calculate in the same way the emissions attached to products purchased by the paper industry to supply the pharmaceutical industry with paper products. This is repeated for all parts of the pharmaceutical supply chain from the purchase of goods, energy and services.

Appendix C – NHS England expenditure reconciliation

(a) NHS England expenditure estimated from the Input-Output (I-O) tables

Column 117 in the I-O table is Government expenditure on 'health and veterinary services', which for 2004/5 is broken down as follows:

- Expenditure at purchasers prices £39.7BN
- staff compensation £46.2BN
- TOTAL £86BN

Of the 39.7+46.2 = £86BN expenditure, £9BN is household expenditure, with the remaining £77BN attributable to government expenditure. Thus the data above is reduced by the fraction 9/86, the resultant Government expenditure on health and veterinary services (equated to UK government expenditure on the NHS) is estimated as follows:

- Expenditure at purchasers prices £34.5BN
- staff compensation £42.0BN
- TOTAL £76.5BN

Thus the NHS England expenditure from Column 117 data is therefore 0.837x£76.5BN= £64.03BN, based on the following assumptions:

- That the expenditure given in column 117 I-O model (£76.5BN) was the total government expenditure on health and veterinary services in the UK.
- That the NHS consumed nearly all of this expenditure, and thus it could be assumed that the £76.5BN expenditure equated to expenditure on the NHS in the UK.
- Based on the mid 2004 ONS estimate of population for England (50.09 million) and the UK (59.83 million), the England/UK fraction is using a population fraction = 50.09/59.83 = 0.837.

(b) Published UK NHS expenditure

The following data has been obtained for the year 2004/5:

- NHS England expenditure = £73.0BN [41]
- NHS Wales expenditure = £4BN [42]
- NHS Scotland expenditure = £7.0BN [43]
- NHS NI expenditure = £2.6BN [44]
- Total = £86.6BN

The ratio of NHS England/UK expenditure is 73/86.6 = 0.843, which is very close to the population fraction of 0.837. assuming similar levels of spending per head of population, this indicates that the expenditure levels are broadly accurate. Actual NHS England expenditure was determined to be £73.0BN from the 2006 DH Departmental report, made up of:

- £4.0BN receipts (eg patient charges)
- £69.0BN government expenditure

[41] *p.31 Department of Health - Departmental Report 2006* Department of Health (2006)
[42] http://www.wales.nhs.uk/documents/agw2004_2es.pdf
[43] http://isd.scot.nhs.uk/isd/new-releases-no-scroll.jsp;jsessionid=A265A83543903481941FABE9B442CB81?pContentID=3767&p_applic=CCC&p_service=Content.show&
[44] http://www.dhsspsni.gov.uk/05-2.pdf

(c) NHS England expenditure reconciliation

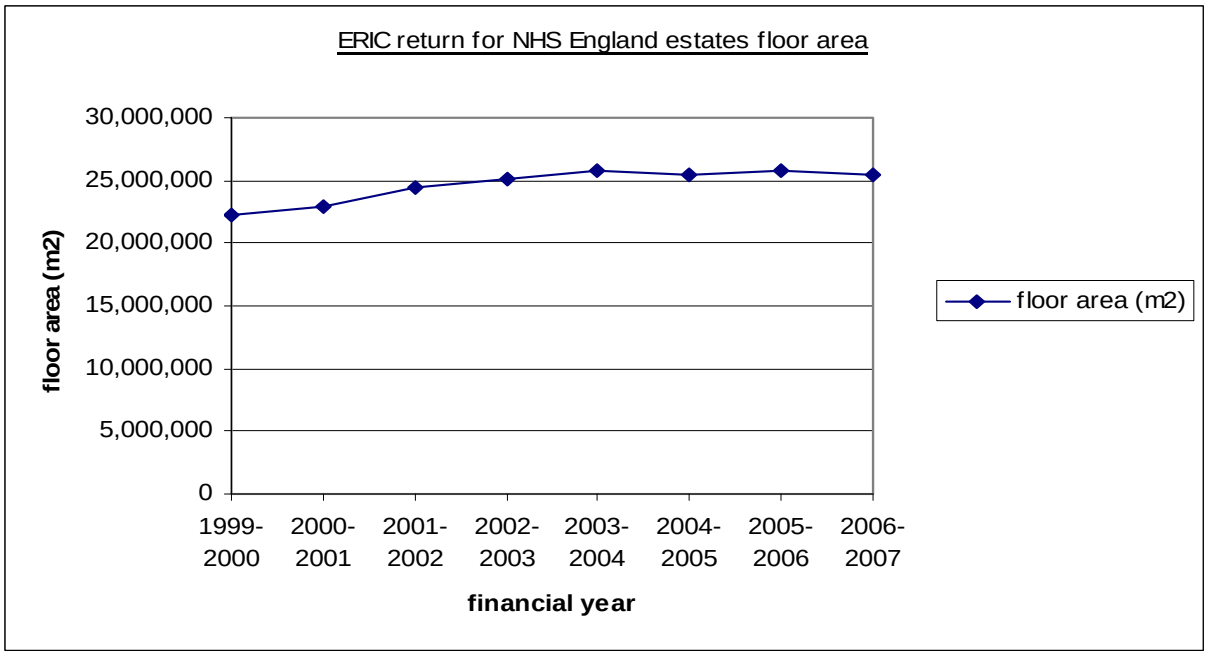
In theory the £64BN calculated from the I-O table should be equal to or greater than the £69BN determined from DH as the NHS England expenditure by Government in 2004/5. This discrepancy could therefore underestimate emissions by 7%. The £4Bn NHS England spending also provides a mechanism for underestimation of NHS England emissions.

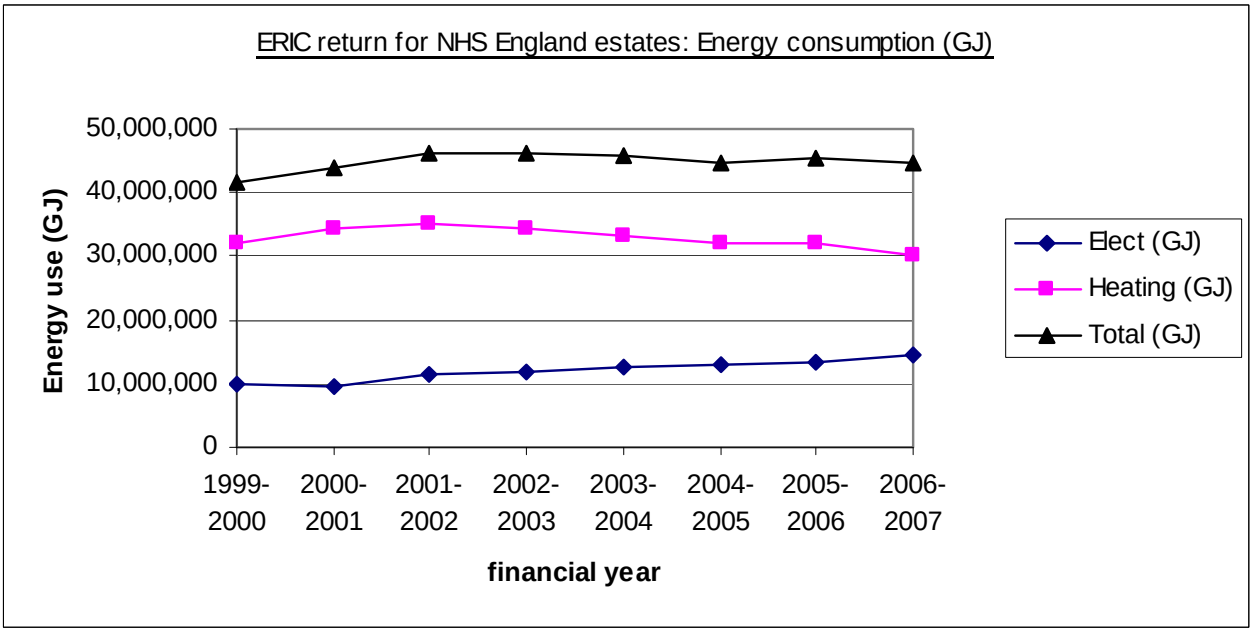
However, in order to conclude if the expenditure based on I-O data is valid, the purpose of the emissions calculations must be borne in mind, which is to provide a method for managing and reducing carbon emissions in the future. The I-O model allows comparisons between years, and also permits the closer examination of emissions from various sectors and sub-sectors. Put another way, if the NHS England emissions using the I-O model reduce to the desired targets, then it is likely (by the policies and practices used to achieve these emissions cuts) that the emissions from any expenditure not captured by the I-O model will also be reduced by a similar proportion.

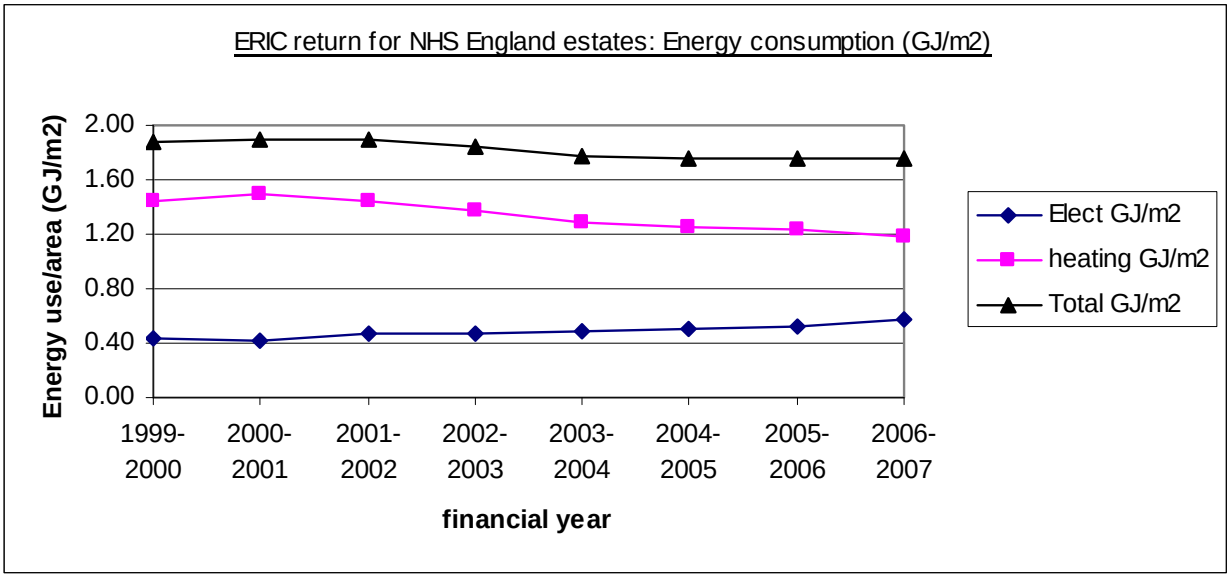
Thus on the basis of practicality and transparency, the I-O expenditure data is considered suitable for the purpose of managing carbon emissions in NHS England.

Appendix D – ERIC data 1999-2006: Electricity and heating energy consumption

		Electrical energy consumed		Heating energy consumed		Total energy consumed	
Year	Floor area (m^2)	Elect (GJ)	Elect GJ/m^2	Heating (GJ)	Heating GJ/m^2	Total (GJ)	Total GJ/m^2
1999-2000	22,284,185	9,737,810	0.44	31,986,503	1.44	41,724,313	1.87
2000-2001	22,998,269	9,513,877	0.41	34,263,706	1.49	43,777,583	1.90
2001-2002	24,369,311	11,283,033	0.46	35,012,468	1.44	46,295,501	1.90
2002-2003	25,173,764	11,836,578	0.47	34,444,607	1.37	46,281,185	1.84
2003-2004	25,813,941	12,413,313	0.48	33,300,672	1.29	45,713,985	1.77
2004-2005	25,428,351	12,901,355	0.51	31,883,822	1.25	44,785,178	1.76
2005-2006	25,803,019	13,493,766	0.52	31,928,935	1.24	45,422,702	1.76
2006-2007	25,486,209	14,582,505	0.57	30,221,369	1.19	44,803,875	1.76




ERIC return for NHS England estates: Energy consumption (GJ)
50,000,000
40,000,000
30,000,000
20,000,000
10,000,000
0
Energy use (GJ)
1999-2000
2000-2001
2001-2002
2002-2003
2003-2004
2004-2005
2005-2006
2006-2007
financial year
Elect (GJ)
Heating (GJ)
Total (GJ)


ERIC return for NHS England estates: Energy consumption (GJ/m2)
2.00
1.60
1.20
0.80
0.40
0.00
Energy use/area (GJ/m2)
1999-2000
2000-2001
2001-2002
2002-2003
2003-2004
2004-2005
2005-2006
2006-2007
financial year
Elect GJ/m2
heating GJ/m2
Total GJ/m2